A STUDY OF ANATOMICAL VARIATIONS IN AZYGOS SYSTEM OF VEINS

Submitted in partial fulfillment for

M.D DEGREE EXAMINATION
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ANATOMY

DEPARTMENT OF ANATOMY
STANLEY MEDICAL COLLEGE
CHENNAI

TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI 600 003
APRIL 2016

CERTIFICATE

This is to certify that the dissertation on **'A STUDY OF ANATOMICAL VARIATIONS IN AZYGOS SYSTEM OF VEINS '** is a bonafide work done by **DR. F. STELINA SOPHIE DINA** in the Department of Anatomy, Stanley Medical College, Chennai 600001, during 2013-2016 under my supervision and guidance in partial fulfillment of the regulation laid down by the Tamil Nadu Dr. M.G.R. Medical University, for the M.D. Anatomy Branch XXIII examination to be held in April 2016.

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CERTIFICATE OF THE GUIDE

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DECLARATION

I solemnly declare that this dissertation **'A STUDY OF ANATOMICAL VARIATIONS IN AZYGOS SYSTEM OF VEINS '** is a bonafide work done by me in the Department of Anatomy, Stanley Medical College, Chennai 600001, during 2013-2016 under the supervision and guidance of Prof. **Dr. S. CHITRA, M.S.,** Professor and Head of the Department of Anatomy, Government Stanley Medical College, Chennai- 600001.

This dissertation is submitted to The Tamilnadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the regulation laid down by the Tamil Nadu Dr. M.G.R. Medical University, for the award of Degree of M.D. Anatomy Branch XXIII examination to be held in April 2016.

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INSTITUTIONAL ETHICAL COMMITTEE,
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Title of the Work : A study of Anatomical variations in azygos system of veins.

Principal Investigator : Dr. F Stelina Sophie Dina

Designation : PG in MD (Anatomy)

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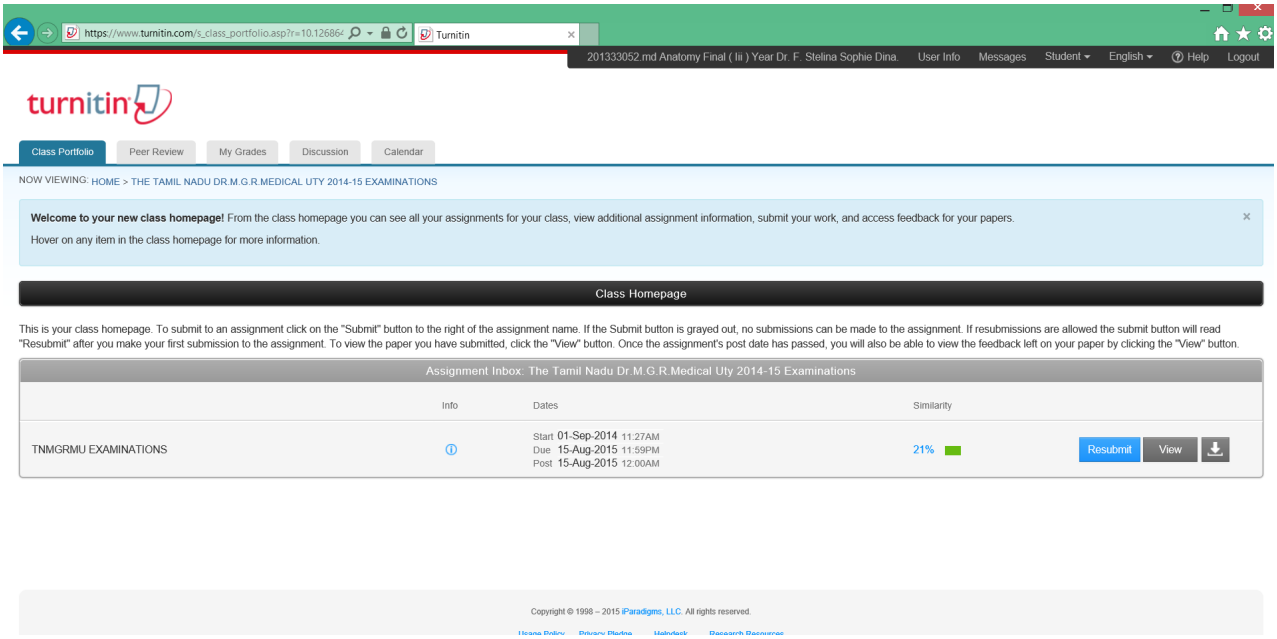
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INTRODUCTION

The name azygos, which is derived from Greek means not paired. The azygos system of veins is not accompanied by the same arteries and is straight in course [17]. The azygos system of veins drain blood from the chest and the abdominal walls and the back.[17,51]

The azygos vein vary in its formation. Azygos vein can be formed from the union of the right ascending lumbar and right subcostal veins (lateral root). After the formation it passes in front of and to the right of the twelfth thoracic vertebra posterior to the right crus of diaphragm. The azygos vein can be formed by medial or intermediate roots from the posterior aspect of inferior vena cava at or below the renal vein level. If it is present the lumbar azygos vein passes anterior to the upper lumbar vertebrae. It then passes posterior to or pierces the right crus of the diaphragm. It sometimes passes through the aortic hiatus. Anterior to the twelfth thoracic vertebral body, the lateral root joins the azygos vein. The azygos vein passes upwards in the right side of posterior mediastinum upto the level of the fourth- fifth thoracic vertebra. It then arches in front of and above the right upper lobe bronchus and the anterior branch of pulmonary artery. Then it terminates in the superior vena cava before piercing the pericardium [34,80].

The hemiazygos vein (inferior) and the accessory (superior) hemiazygos vein are tributaries of the azygos vein [17]. The combination of left

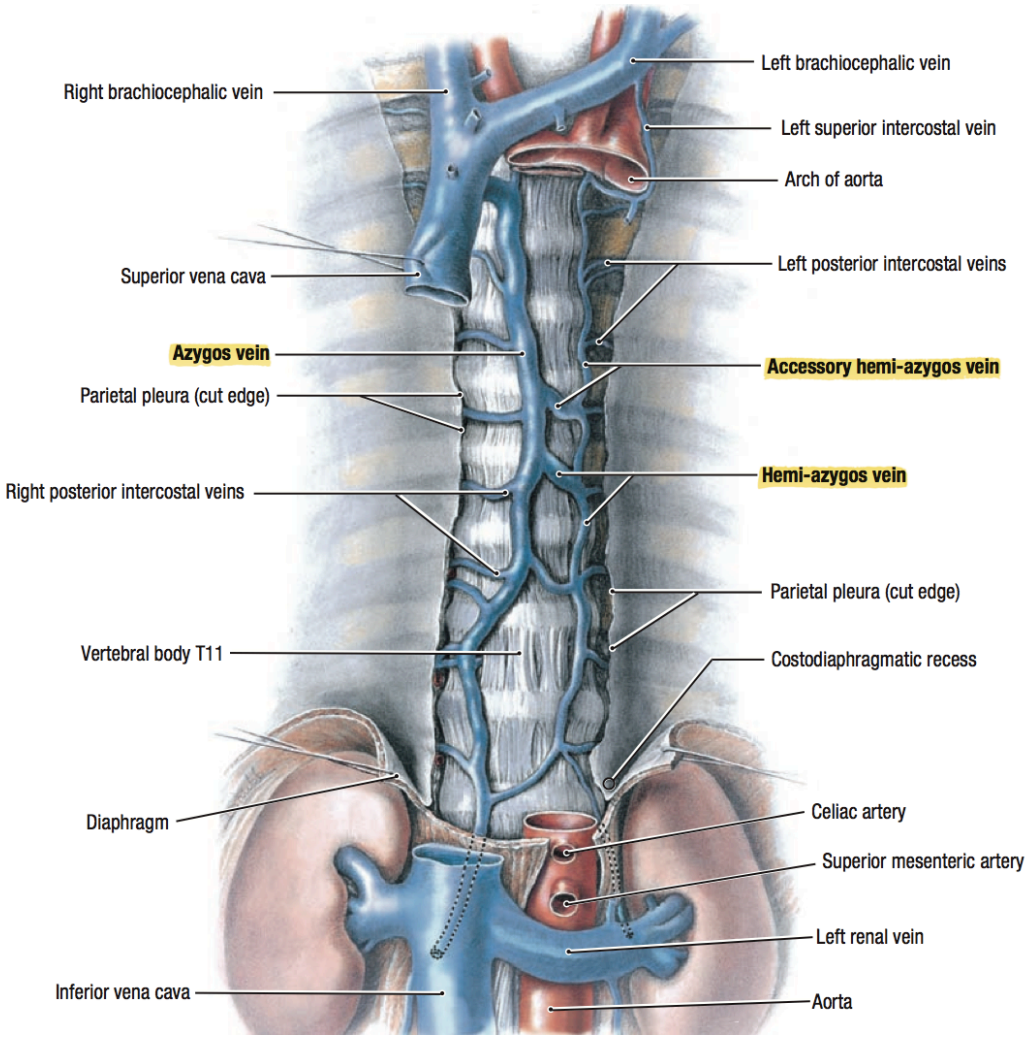


Figure A: AZYGOS SYTEM OF VEIN DEPICTING THE AZYGOS VEIN AND ITS MAIN TRIBUTARIES, THE HEMIAZYGOS VEIN AND THE ACCESSORY HEMIAZYGOS VEIN AND OTHER TRIBUTARIES

ascending lumbar and left subcostal veins forms the hemiazygos vein. Sometimes it may have communication from the left renal vein [67] or the inferior vena cava. It then passes anterior to the vertebral column and crosses posterior to the oesophagus, aorta and thoracic duct at the level of eighth thoracic vertebra. It then terminates in the azygos vein. The left lower four posterior intercostal veins (8th, 9th, 10th and 11th) terminate into the hemiazygos vein.

The accessory hemiazygos vein is formed by the combination of fourth or fifth to eighth left posterior intercostal veins. It crosses usually at the seventh thoracic vertebral level to end in the azygos vein. The accessory hemiazygos vein occasionally receives the left bronchial veins. It can join the hemiazygos vein and the common trunk ends in the azygos vein [67]

The azygos venous system forms the vein network of the trunk. In pathologic situations it functions as alternative pathway [19,49] (Mezzajiorno, Dudiack). When inferior venacava obstruction is present azygos vein forms alternative pathway for veins below the diaphragm except the digestive system [7,9,17, 59]. (Kadir, Aziz khan, Schultz, Bechtold). Also, in obstruction of superior vena cava it forms an alternative pathway with inferior venacava [19,23,49]. Thus, the azygos vein forms communication between the superior and inferior vanacava with the ascending lumbar veins and their tributaries.

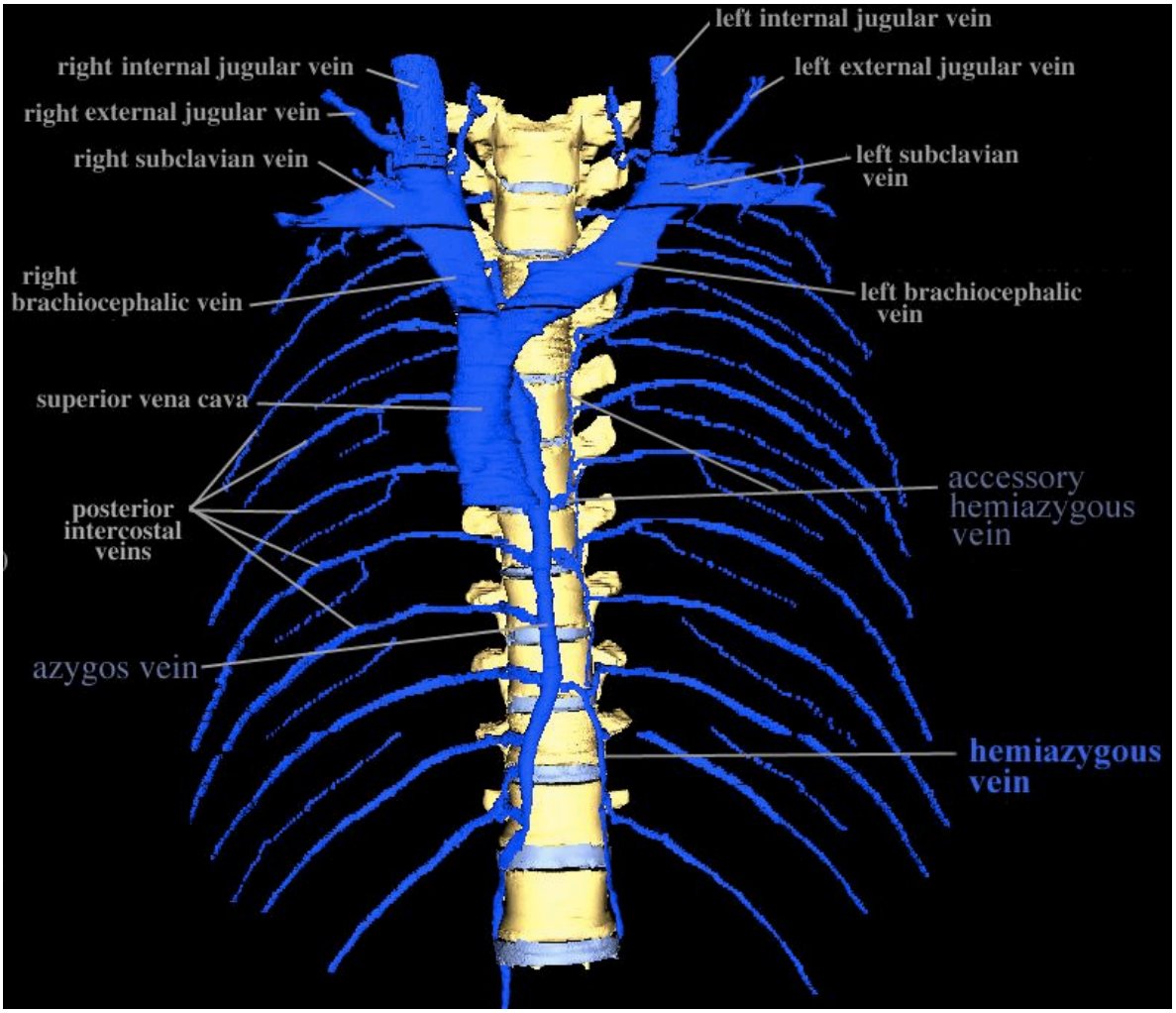


Figure B: THE AZYGOS VENOUS SYSTEM

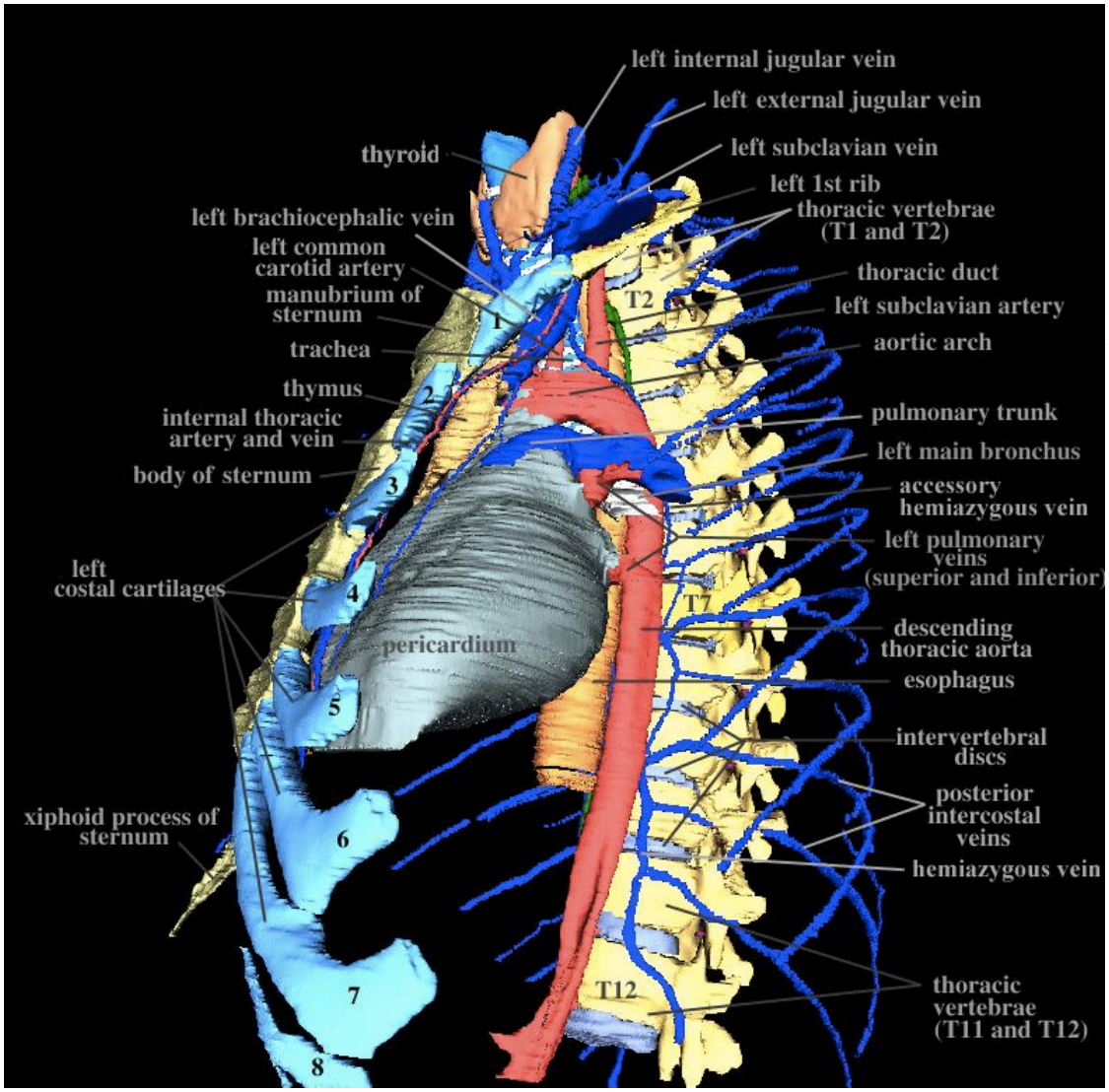


Figure C: SAGITTAL VIEW SHOWING THE HEMIAZYGOS AND THE ACCESSORY HEMIAZYGOS VEINS AND THE POSTERIOR INTERCOSTAL VEINS

portal venous system gives blood flow to the superior vena cava through the oesophageal veins. The alternative veins in the retroperitoneal region, the venous plexus of Retzius, communicate the veins of duodenum, spleen, transverse colon, and pancreas with the inferior phrenic vein and the azygos vein [64,67, 71,73].

It also communicates the cerebral vein system and vertebral venous plexuses with the intercostal veins. This has significance because of venous metastatic pathways in breast and bronchial cancers.

AIM OF THE STUDY

Variations are commonly seen in the azygos system of veins because of its complicated embryological development [39,43,46,63].

The aim is to study the variations of azygos system of veins under the following parameters

1. Mode of formation of the azygos vein
2. Course of the azygos vein in relation to the midline of vertebral column.
3. Level of arching of the azygos vein and level of termination of azygos vein into the superior venacava.
4. Level of termination of the hemiazygos vein, the accessory hemiazygos vein.
5. Diameter of the azygos vein, the hemiazygos veins at the level of termination.
6. Type, pattern of the azygos system of veins

It is important to keep these kinds of variations in mind while performing the mediastinal operations or the operations involving large vessels in this region [71]. (Kutoglu et al 2012).

Accidental injury to venous anomalies, which are developmentally present, can lead to excessive bleeding during surgical procedures.[11] (Brenner, Clement 1974).

Although there are various surgical approaches to deal with this situation it is best to avoid such situations. A knowledge of such venous anomalies prior to surgical procedures can be useful to surgeons. This helps especially while operating on the posterior mediastinum.

An anatomical knowledge of these developmental venous anomalies is important for radiologists. These structures can be misinterpreted as an aneurysm, enlarged lymph node or tumor in computed tomography and magnetic resonance imaging scans [13] Celik (1996). It stresses the need to use various radiological procedures to obtain pre-operative scans of the venous system.

Surgeons should have knowledge of these variations during operations in mediastinum to avoid severe bleeding**.** Also the congenital venous anomalies can be one of the reasons of thromboembolic disease particularly in young people with no other related risk factors for it. [55] (Ordonez, 1999).

The variant azygos veins that are continuous with inferior venacava are associated with anomalies of heart, spleen and superior vena cava[50]

(Minniti et al., 2002). This can cause difficulty in diagnosing these structures in scans and magnetic resonance imaging scans [64] (Smathers, 1983).

REVIEW OF LITERATURE

1. MODE OF FORMATION OF THE AZYGOS VEIN

The formation of azygos vein is variable [13] (Celik et al, 1996) due to the complexity in its embryological development [49](Mezzogiorno and Passiatore, 1988).

Formation by the three roots:

It can be formed as a single root, two roots and three roots. Eight veins can combine differently in the formation. The three roots are named the lateral, intermediate and the medial roots.

Lateral root is the common trunk formed by the combination of right ascending lumbar vein and right subcostal vein in the thorax. It is formed at the level just below the head of twelfth rib [54,63] (Seib 1934, O'Neil, 1945).

Intermediate root (lumbar azygos) is from posterior aspect of the inferior vena cava. It passes upwards and joins the lower end of azygos vein [63] (Seib, 1934).

Medial root communicates with the inferior vena cava or the left renal vein at the lower end. It communicates with the intermediate azygos root at the upper end. Sometimes it can arise from the posterior aspect of the inferior vena cava as common medial root. It then passes through the aortic opening of diaphragm and divides into medial azygos root and medial hemiazygos

root forming a Y shaped pattern [63] (Seib, 1934).

According to George A Seib (1934) [63] study, the incidence of lateral root in the formation of the azygos vein is 94%. For the intermediate root it is 45% and medial root it is 39%.

Testut & Latarjet (1959), states that only the continuation of the right ascending lumbar vein forms the azygos vein [75].

According to Testut & Jacob (1964), the right ascending lumbar vein continues upwards as the azygos vein [74].

Azygos vein is formed mostly by the combination of the right ascending lumbar and the right subcostal vein [44] Lockert et al (1965)

Spalteholz (1967), states that the right ascending lumbar vein forms the lateral root of the azygos vein [65].

Hollingshead (1971) states that mostly the lateral root forms the azygos vein [34]. The lateral root is from the combination of the right ascending lumbar and the right subcostal vein. It may have at times communication with the inferior venacava.

Azygos vein is formed mostly from the union of the right ascending lumbar vein and the right subcostal vein [21,26], Gardner et al (1978), E.R.Heitzman, The Mediastinum. The lumbar veins communicate with the ascending lumbar vein.

According to Hamilton (1982) [32] the right subcostal vein does not take part in the formation of the azygos vein. It is considered as a tributary of the azygos vein.

Woodbourne (1984) states that the azygos vein formation is by three roots, lateral, intermediate and medial roots [81]. The lateral root is from the union of the right ascending lumbar vein and the right subcostal vein. Intermediate root is a vein communicating with the inferior venacava. Medial root is either by the combination of the pre-vertebral veins or communications with the superior lumbar veins or the inferior venacava.

According to Woodbourne (1984) [81], the incidence of the lateral root was 94% in the formation of azygos vein. It was 45% for intermediate root and 30% for medial root.

Bergman RB et al (1988) [10] states that lateral root in 85% specimen takes part in the formation of the azygos vein. For the intermediate root it is 34% and for the medial root it is 38%.

Gray & Goss (1988) [30] states that azygos vein is formed by the upward continuation of the right ascending lumbar veins.

Latarjet & Ruiz Liard (1989) [41] states that the lateral root is formed from the combination of the right ascending lumbar and the right subcostal vein.

Also a medial root, which is variable, may arise from either the right renal vein or the inferior venacava.

According to Williams (1995) the formation of the azygos vein is most commonly by the combination of the right ascending lumbar and the right subcostal vein [80].

During operations in the mediastinum and in interpretation of the radiographs the variation in the formation and course of azygos system of veins should be kept in mind [11] (Brenner et al, 1974).

Williams et al. (1995) states that the azygos vein can be formed as the lumbar azygos from the posterior aspect of inferior venacava [80]. It can also be formed as a single common trunk by the combination of the right ascending lumbar vein and the right subcostal vein.

According to Williams (1995), the azygos vein can be formed from the lumbar azygos. In that situation the common trunk formed by the combination of the right subcostal vein and the right ascending lumbar vein forms the main tributary of the azygos vein.

According to Di Dio (1999) [18], the azygos vein is the upward continuation of the right ascending lumbar vein. Di Dio states that the right subcostal vein is a tributary of azygos vein. It does not take part in its formation.

In Elton Correia Alves et al (2011) [2] study the common structure noted in the formation of the azygos vein is the right subcostal vein (93.3%). Out of 30 specimens studied azygos vein is formed only from the subcostal vein in 43.3% specimens It is formed from the combination of the right subcostal vein and the right ascending lumbar veins in 10% of the specimens. It is also formed from the right subcostal vein with communication from the inferior venacava; from the right subcostal veins and the right ascending lumbar veins with communication from the inferior venacava in 10% each among all the specimens.

The left renal vein in 3.33% of the specimens forms it. It is also formed by the combination of right and left subcostal veins with communication from the inferior venacava in 3.33% of the specimen. It is formed by the combination of the right and the left subcostal veins and the left accessory renal vein; by the combination of the right subcostal veins and left renal veins in 3.33% each. The upward continuation of the 11th posterior intercostal vein forming azygos vein is present in 3.33% specimens. The combination of the right subcostal vein and left gonadal veins with a communication from the inferior venacava is seen in 3.33% specimens. It is formed by the right and left subcostal in 6.66%. Left subcostal vein participated in formation of the azygos vein in 13.3%.

According to Elton Correia Alves et al (2011) azygos vein is formed by single root in 50%. Two roots form it in 30% and by three roots in 20%.

According to Seema et al (2013) Y shaped pattern is seen in medial root. This divided into medial azygos, and medial hemiazygos from which azygos and hemiazygos veins formed respectively. This is a very rare variation [(61)].

Kanchana Latha et al (2013) [(69)], states that in the 100 specimens studied, the formation of the azygos vein is only by the lateral root (100%). The lateral root is formed by combination of the right ascending lumbar vein and the right subcostal vein in 88% and by only the right subcostal vein in 12%.

2. COURSE OF THE AZYGOS VEIN IN RELATION TO MIDLINE OF THE VERTEBRAL COLUMN

In Nathan H (1960) [53] study, in 20% of adult cadavers the azygos vein is on the right and in 27% at the midline. It is present in 53% on the left of the midline.

Hollingshead (1971) [34] states that the azygos vein normally passes upwards on the right side of the vertebral column before it terminates into the superior vena cava.

Bergman et al (1988) [10] states that where the hemiazygos vein and accessory hemiazygos vein are not fully formed, the left posterior intercostal veins terminate into the azygos vein which is present at the midline.

In Kagami (1990) [39] study, in 4% of adult cadavers, the azygos vein is on the right and 11% at the midline. The azygos vein crosses to the left side in 85%.

According to Elzbieta Krakowiak Sarnowska et al (2003) [22] studies, out of 32 human foetuses the azygos vein is present on right side in 90.6% and on the midline in 9.4%.

According to Tatar et al (2008) [36] the azygos vein is on the right side of

midline in 37.9 % and the mean distance from the midline is 6.4 mm. In 22.3% the azygos vein is on the left side of midline and the mean distance from the midline is 7.5 mm. In the 39.8 % it is at the midline and anterior to the vertebral column.

3. LEVEL OF ARCHING OF THE AZYGOS VEIN AND LEVEL OF TERMINATION INTO THE SUPERIOR VENACAVA

In the study of the level of the azygos arch in 200 cadavers by Seib (1934) 33.6% of azygos arch are at fifth thoracic vertebral level and 32.6% are at intervertebral disc of fourth and fifth thoracic vertebra. [63]

The reference point related to arching of the azygos vein is said to be over the right main bronchus [34] Hollingshead (1971).

Kadir et al (1991) [38] observes the termination of the azygos vein into the superior venacava seen at fourth and fifth thoracic vertebral levels.

According to Elzbieta Krakowiak Sarnowska et al (2003) [22] studies, out of 32 human foetuses the azygos vein drains mostly at the fourth thoracic vertebral level (81.25%). It terminates in 12.5% of cases on third thoracic vertebral level, and in 6.25% of cases on fifth thoracic vertebral level.

According to Tatar et al (2008) [36] the termination of the azygos vein into the superior vena cava is between the fourth and sixth thoracic vertebrae. The azygos arch before it terminates into the superior vena cava is at the fourth thoracic vertebral level in 40%of the specimen. It was at the fifth thoracic vertebral level in 55% and at sixth thoracic vertebral level in 5% of the specimens. The level of draining of azygos vein into superior venacava

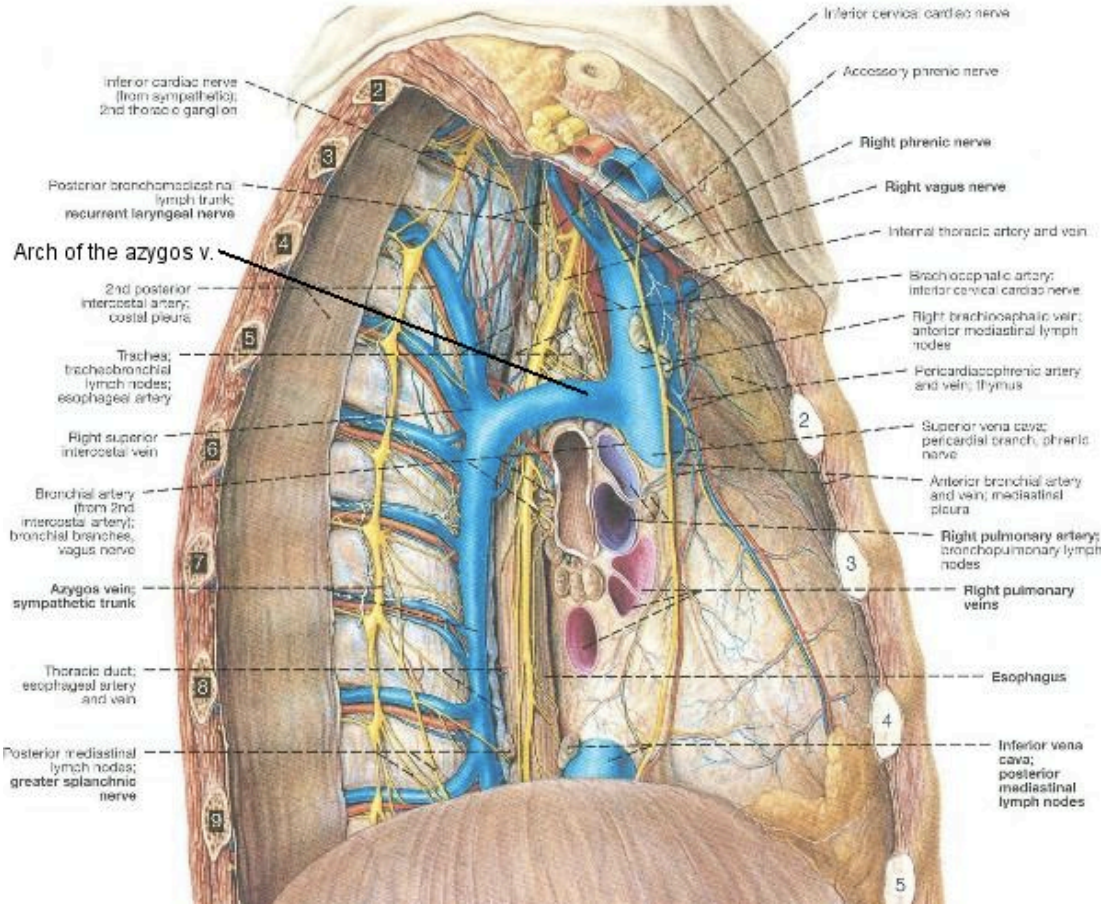
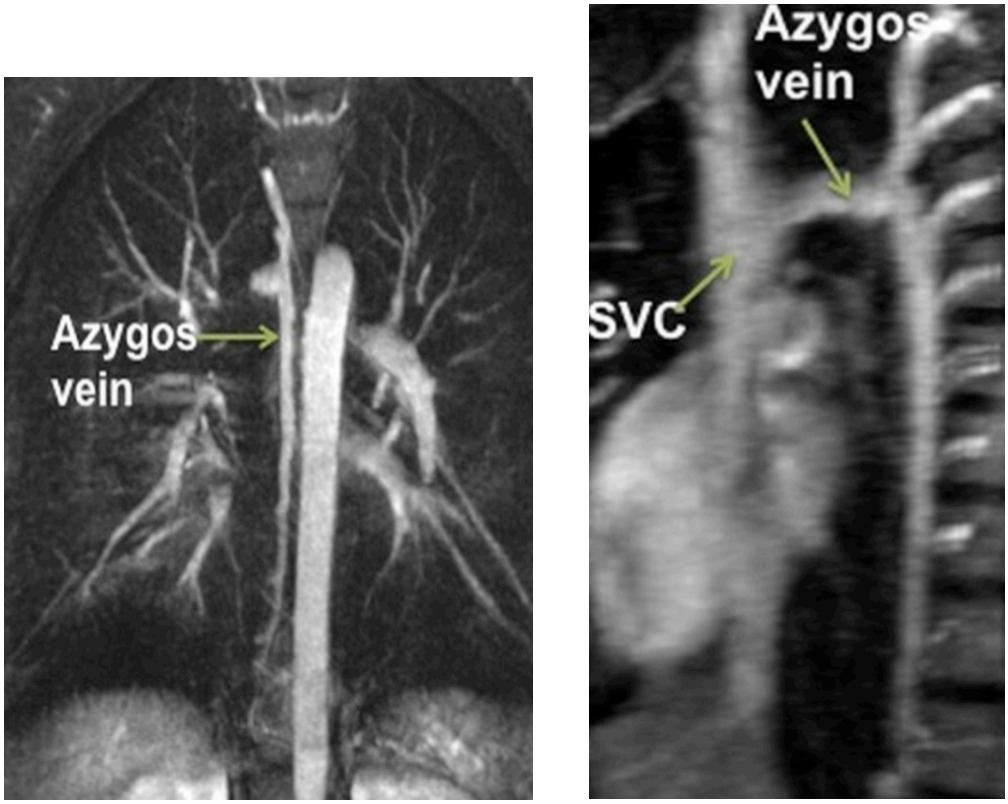


Figure D: PICTURE SHOWING THE AZYGOS ARCH- THE AZYGOS VEIN TERMINATING INTO THE SUPERIOR VENACAVA



- ***Figure E:*** ***RADIOGRAPHIC IMAGES SHOWING THE AZYGOS VEIN AND ITS TERMINATION INTO THE SUPERIOR VENACAVA- Normal anatomy of the azygos venous system, illustrated at gadolinium-enhanced 3D MR angiography with coronal (a) and sagittal (b) maximum-intensity projection (MIP) images References: Radiology, Centro Hospitalar e Universitário de Coimbra, Hospitais da Universidade de Coimbra - Coimbra, Portugal***

is between fourth and sixth thoracic vertebral levels just below the carina.

The azygos vein enters the thorax through the aortic opening in the diaphragm and passes upwards in the posterior mediastinum. It terminates into the superior vena cava at the level of the 4th thoracic vertebra (Strandrings 2008) [67]

According to Kutoglu (2012) study [71], out of 48 cadavers studied, the termination level of the azygos vein is at the level of third thoracic vertebra in 66.7%. It terminates at the second thoracic vertebral level and at the level of intervertebral disc between second and third thoracic vertebra in 13.3% each among all the specimens. The termination level is at the level of intervertebral disc between third and fourth thoracic vertebra in 6.7% specimens.

According to Kanchana latha et al (2013) [69] study, among the 100 specimens studied the termination of azygos vein is seen at the fourth thoracic vertebral level in 85%. It was at third thoracic vertebral level in 8% and fifth thoracic vertebral level in 7% of specimens.

Lobe of the Azygos Vein:

Weisberg in 1777 wrote about the lobe of the azygos vein, in a 3yr old boy cadaver. This is also known as “Lobe of Weisberg” (Mather, 1928, AGN, 1931; George Bray, 1932;) [1,6,27,47]

Figure F: THE LOBE OFAZYGOS VEIN-ANTERIOR AND SUPERIOR VEIW OF THE RIGHT LUNG, REFERENCE: Ashwini et al. Indian Journal of Medical Case Reports ISSN: 2319–3832(Online) 2013 Vol.2 (3) July-September, pp.11-13

The incidence of the lobe of the azygos vein of the right lung in routine Anatomic dissections is 1%. It is 0.4% in Chest radiograms. Radiographically it is seen as a fine convex line from the right apex. This line curves downwards and inwards to the mediastinum. It ends just below the level of the first costal cartilage as a dense comma shaped shadow. (George Bray, 1932) [27]

The importance of the lobe of the azygos vein as a variation is significant clinically. (Lupu G et al, 2012) [45] Any patient with insufficient or incorrect imaging studies can have a wrong diagnosis, such as a malignant space-occupying lesion.

Ashwini et al (2013) [6] has noted the presence of lobe of the azygos vein in the right lung in routine dissection.

The lung parenchyma that is medial to the accessory fissure is called azygos lobe or Adam`s lobe. (Lenoir V et al, 2013) [42]

Sometimes the azygos vein comes out of the fissure (migrating azygos) and lies in a paramediastinal position. It may be due to lung collapse, spontaneous pneumothorax, increased intrathoracic pressure, or due to sudden development of kyphosis. (Lenoir et al, 2013) [42]

According to Sara Piciucchi et al (2014) lobe of the azygos vein in the right lung is present in 0.4- 1% of the population. It is due to incomplete medial

migration of right posterior cardinal vein [58].

In surgical procedures involving the superior lobe of right lung the possibility of lobe of the azygos vein should be considered. This is to avoid injury to the azygos vein or its tributaries. Discovery during the necropsy of excessive bleeding made by accidental injury to the azygos vein, in this region, suggests a pre-operative incorrect diagnosis.

4. LEVEL OF TERMINATION OF THE HEMIAZYGOS AND THE ACCESSORY HEMIAZYGOS VEIN

Kadir et al (1991) [38] states the termination of hemiazygos vein at seventh thoracic vertebral level.

According to Elzbieta Krakowiak Sarnowska et al (2003) [22] out of 32 human foetuses the hemiazygos vein drains mostly at the level of eighth thoracic vertebral level (35.7%) . The termination of the hemiazygos vein into azygos vein is 18.7% at the ninth thoracic vertebral level. It is 17.8% at tenth thoracic vertebral level and 14.2% at seventh thoracic vertebral level respectively. 3.5% terminates at fifth, sixth and eleventh thoracic vertebral levels each. The termination of the accessory hemiazygos vein into the azygos vein is mostly at seventh thoracic vertebral level (41.6%). 29.2% drains at the sixth thoracic vertebral level. The termination is 25% at the eighth thoracic vertebral level and 4.2% at the fifth thoracic vertebral level respectively.

In the Kutoglu et al (2012) [71] study, in 27.1 % of specimens the drainage of the hemiazygos vein is at eighth thoracic vertebral level.

According to Kanchana latha et al (2013) [69] hemiazygos vein crosses the midline towards the right side and terminates at the level of eighth thoracic vertebra in 70 % of specimens and at ninth thoracic vertebral level in 3 % of specimens.

5. DIAMETER OF THE AZYGOS AND THE HEMIAZYGOS VEINS AT THE LEVEL OF TERMINATION

Determining the normal diameter of the azygos vein is important considering the various clinical conditions affecting it, for example infiltrations due to malignancy and aneurysms. Westra (1985), Barraine (1981) [8,79]

Trigaux et al (1995) [76] measures the diameter of the azygos vein in normal subjects. In subjects with lung sequestration and subjects with lung opacity also the diameter of azygos vein is measured and compared. It is measured at the midpoint between the upper pole of kidney and the inferior pulmonary vein. In the normal group the diameter of the azygos vein is 10.4 ± 5 mm. In cases with posterobasal opacity it is larger.

According to Tatar et al (2008) [36] study, Azygos vein diameter just at the termination into the superior vena cava is between 4.3 mm and 16 mm. The mean diameter is 8.1 mm. It is 8.2 mm in males and 7.8 mm in females.

The diameter of azygos, hemiazygos veins at the termination is four times the diameter at the formation in the study of Tatar et al (2008).[36]

Kutoglu et al (2012) [71] study states the mean diameter of the azygos vein as 8.56±1.26 mm at its termination. The mean diameter is 5.65±1.17 mm for the hemiazygos vein at its termination. For the accessory hemiazygos

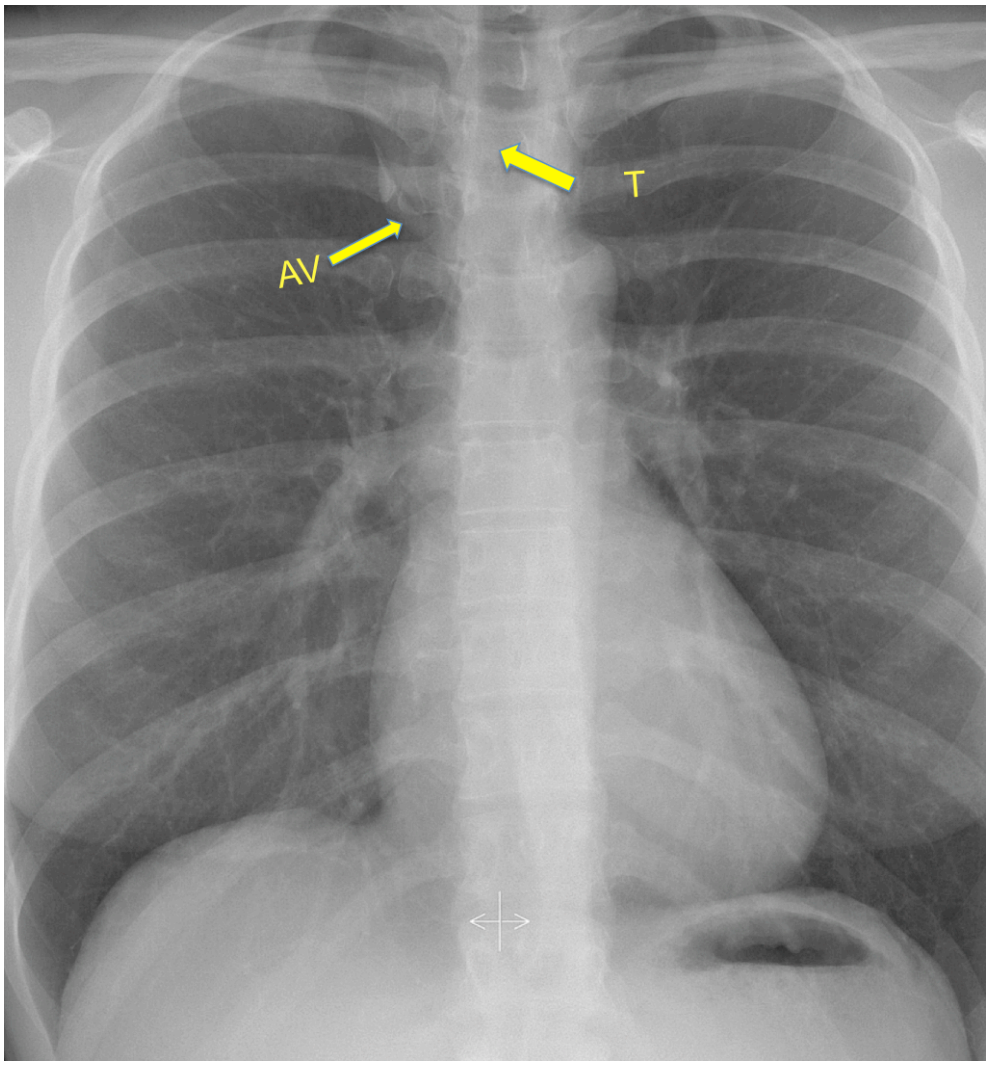


Figure G: ***CHEST X RAY PA VIEW SHOWING AZYGOS IMPRESSION,*** ***AV-AZYGOS VEIN, T- TRACHEA***

vein it is 5.47±1.16 mm at its termination.

According to Fleischner's observation, the azygos vein can be seen in 75 % of normal chest X- rays [32]. It normally measures about 0.9 cm.

Dilation of the azygos vein may be attributed to pregnancy, cardiac decompensation and portal hypertension. It may also be due to congenital anomaly of the venacava or acquired obstruction that may be secondary to tumor or thrombus. In such situations, high blood flow or additional pressure from using the azygos system as an alternative vein may lead to long tubular dilatation of the azygos vein (Watanabe A, Icard P, Mehta M) [35,48,78]

Idiopathic azygos vein aneurysm is rare. Less than fifty cases have been noted. Because azygos vein aneurysms are usually without symptoms, most are discovered by chance on chest roentgenograms. The clinical presentation of the azygos vein aneurysm is related to its structural characteristics. Saccular aneurysms that are large usually present with chest symptoms because of mass effect in the mediastinum. Azygos vein aneurysms mimic as mediastinal masses or right lower paratracheal nodules on chest roentgenograms (Sheung –Fat Ko 2014). [62] Differential diagnoses can be thymoma, tumours involving nerves, lymphoma, lymphadenopathies and congenital or acquired arterial or venous lesions (Westra, Barraine). [8,79]

The diameter of the azygos vein can be large at formation level than at the termination level in some individuals. It can be due to a retrograde flow. Increase in intra thoracic and intra-abdominal pressure can have impact on the direction of blood flow in the azygos system (Kanchana Latha 2013).[69]

6. TYPE, PATTERN OF THE AZYGOS SYSTEM OF VEINS

Azygos system of veins is variable due to its complex embryological development.

Lindsay et al (1925) [43] study notes the abnormal hemiazygos vein.

Gladstone et al (1929) [29] study on development of inferior vena cava states the abnormalities in the ascending lumbar and the azygos vein.

Seib GA (1934), Anson BJ (1977), Falla A et al. (1963) classifies the azygos vein system as three types and its subgroups [5,24,63]. Seib GA (1934) [63] study analyses 200 dissected specimens. In this study azygos venous system is classified in three main types and 21 subtypes. This study also states the main types as the double column, transition and the single column types. In this study [63], 58% has double type, 37 % has transitional type and 5% has single type of the azygos venous system.

In an earlier study of 195 cadavers, preaortic crossing of the interazygos vein is noted in 3.6% of the cases [63] Seib (1934).

Morton et al (1948) [52] observes pre aortic communicating channel between the azygos vein and the hemiazygos veins.

Falla A et al (1963) [24]. in their study of 100 cadaver dissections have classified the results in 11 groups.

In his study of 100 cadaver dissections, Anson BJ (1966) [4] has classified

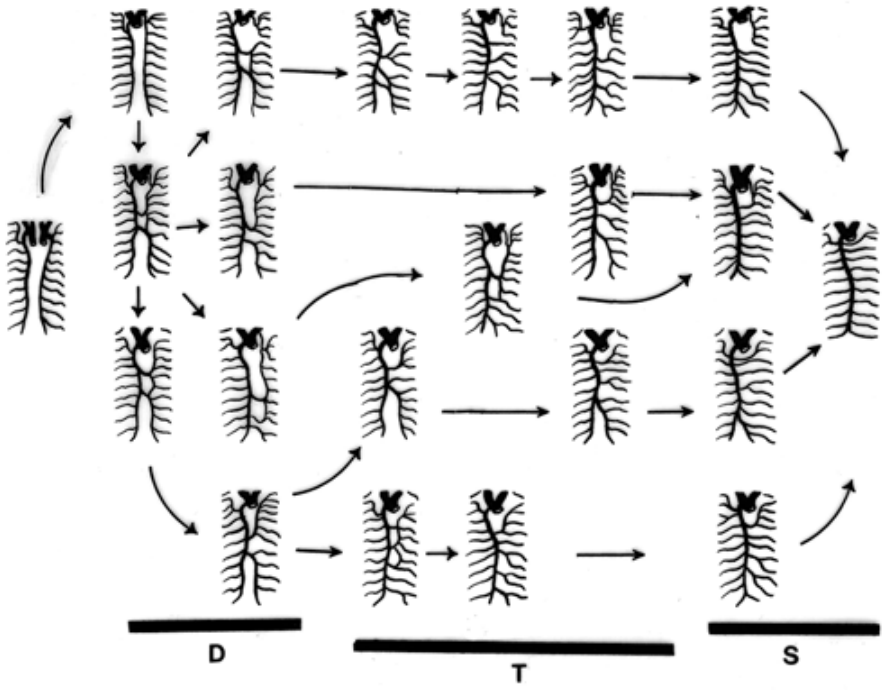


Figure H: THE AZYGOS VENOUS SYSTEM - the azygos venous pattern. A diagrammatic representation of the twenty-one different types of arrangement found in 200 cadavers, Seib 1934

the azygos system of veins in three main types and 11 subtypes. Type I is primitive form. It is also considered the embryological form. It consists of two separate veins lying parallel to each. It is present in 1%. There is only one subtype (Group 1) belonging to this type. Type II is known as the transition type. 98% of all cases are in this form. It consists of Groups 2–10. From Group 2 to Group 5 the retro aortic transverse communication increases and between Groups 6 and 10, the number of the transverse communication decreases gradually. In Type III there is a single azygos vein lying at the midline. It has only one subtype (Group 11). It is seen in 1% of all cases.

Grzybiak et al. (1975), [31] have found the anomalies of azygos veins in 25% of cases.

According to Grzybiak (1975) normally azygos vein is present on right side. There is at least some representation of hemiazygos vein on left. The hemiazygos vein varies from being absent to incompletely formed. The hemiazygos vein is more variable in its origin and course than the azygos vein [31]

The incidence of preaortic communications in the azygos venous system is observed to be 2.5% Grysback (1975) [31]

The first observed case of preaortic crossing of the interazygos vein was seen in a 53-year-old male in computed tomography [64] Smathers (1983).

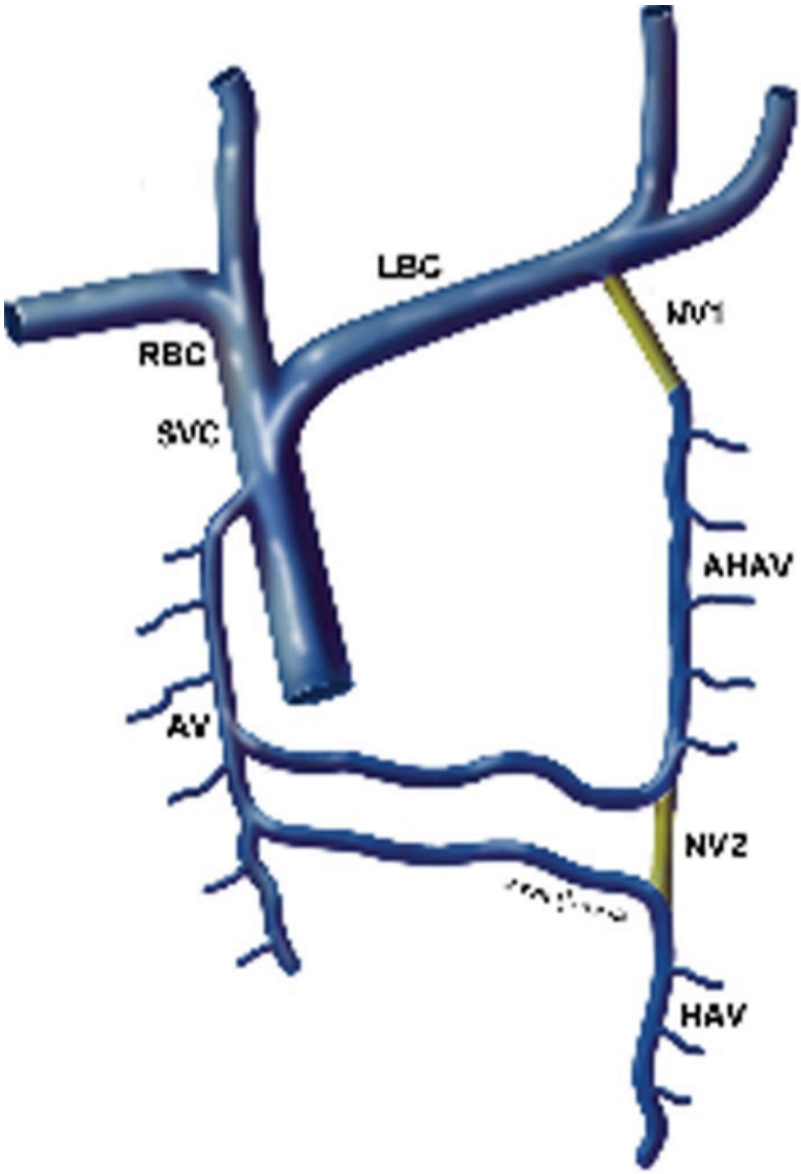
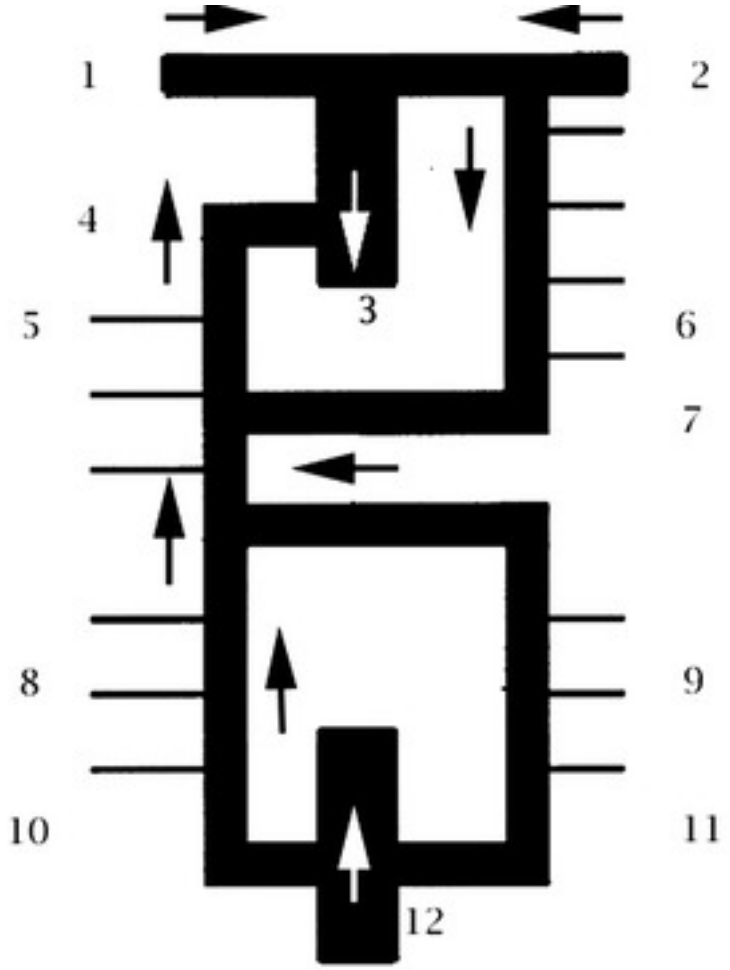


Figure I: DIAGRAMMATIC REPRESENTATION OF THE AZYGOS VENOUS SYSTEM, The blue represents normal venous anatomy. The yellow lines represent the normal variants, *AV- AZYGOS VEIN, HAV- HEMIAZYGOS VEIN, AHAV- ACCESSORY HEMIAZYGOS VEIN, SVC- SUPERIOR VENACAVA, LBC- LEFT BRACHIOCEPHALIC VEIN, RBC- RIGHT BRACHIOCEPHALIC VEIN*



1- Right brachiocefalic vein 2- Left brachiocefalic vein 3- Superior vena cava

4- Azygos vein 5- Right posterior intercostals 6- Left posterior intercostals

7- Accessory HV 8- Right segmental lumbar veins 9- Left segmental lumbar veins

10- Right ascending lumbar 11- Hemiazygos vein 12- Inferior vena cava

Figure J: THE AZYGOS VENOUS SYSTEM- A SCHEMATIC REPRESENTATION

The course of azygos vein is variable [4,10,13,56,57,80] In Woodbourne (1984) study out of 200 specimens the variation from the normal pattern is seen in 26% of the subjects. [81] They are due to embryological development (Moore, Persaud) [51]

Anson BJ (1984) states that retro aortic transveretebral communications from hemiazygos vein and accessory hemiazygos vein to the azygos vein are very variable. It can vary from one to five or more connection. When either accessory hemiazygos vein or inferior hemiazygos vein is absent left intercostal veins cross the vertebral bodies and end in the azygos vein. As the azygos vein is commonly ventral to the vertebral column and sometimes passes left of the midline, these can be very short .[5]

According to Woodbourne (1984) the hemiazygos veins and accessory hemiazygos veins are incompletely formed in 15% of individuals [81]

Cossina et al (1986) [15] have reported two azygos veins that have continuation with inferior vena cava.

Mac Mahon et al (1987) [46] study states that congenital absence of the azygos vein is a cause for aortic nipple enlargement.

Bergman et al (1988) [10] study observes the incidence of the variant branching pattern of azygos vein in 26% of specimens.

Chiiba et al (1990) [14] study observes a rare case of persistence left azygos

vein in a left lung.

The cases of single column azygos vein is observed in 1–2% by Kadir S (1991) [38]

Type I anomaly of the azygos venous system results due absence of subcentral veins and the persistence of the left azygos line [80]. (Williams et al., 1995)

According to Celik et al (1996) [13] anatomical knowledge about the anomalies of azygos systems of veins are important in radiological diagnosis like computed tomography and magnetic resonance imaging scan techniques. The knowledge also helps in the surgical treatment of aneurysms of thoracic aorta and posterior mediastinal tumours.

Ozbeck et al (1999) [56] has noted absence of hemiazygos vein. The left posterior 8th, 9th, and 10th intercostal veins join to form a common trunk. This crosses the vertebral column anterior to the aorta and posterior to the oesophagus and terminates into the azygos vein at the level of seventh-eighth thoracic vertebrae.

Ozdemir et al (2002) [57] reports preaortic interazygos vein. It lies anterior to the aorta and posterior to the oesophagus. It terminates into the azygos vein at fourth thoracic vertebral level. The hemiazygos vein is not formed fully.

Srijit Das (2004) [66] observes hemiazygos vein that is formed by the 9th - 11th intercostal veins to form a dilated interazygos vein. It crosses anterior to the aorta to open into the azygos vein on the right side.

In the compendium of Human Anatomic Variations, the following variations have been reported in azygos system of veins.

(i) The azygos vein terminates into the right brachiocephalic vein.

(ii) It sometimes terminates into the right subclavian vein

(iii) The azygos may end in the hemiazygos that in turn terminates into the right atrium.

(iv) The pulmonary veins can terminate into the azygos vein.

(v) The azygos vein may be absent or it may be double at times .

(vi)The inferior vena cava if it continues into the azygos vein, it is very large.

(vii) The testicular vein, the left renal and suprarenal veins may end in the azygos vein. Standring (2005). [67]

Pyrzwoski et al (2007) [37] has observed preaortic interazygos vein.

The interazygos vein, which passes anterior to the aorta, may mimic enlarged lymph nodes and cause misinterpretation of a computed tomography image. If damaged accidentally during surgery in mediastinum it may lead to intraoperative haemorrhage.

According to Tatar et al (2008) [36] hemiazygos veins are present in 87.4%; 55.5% in males and 44.5% in females. Hemiazygos vein is absent in 12.6%

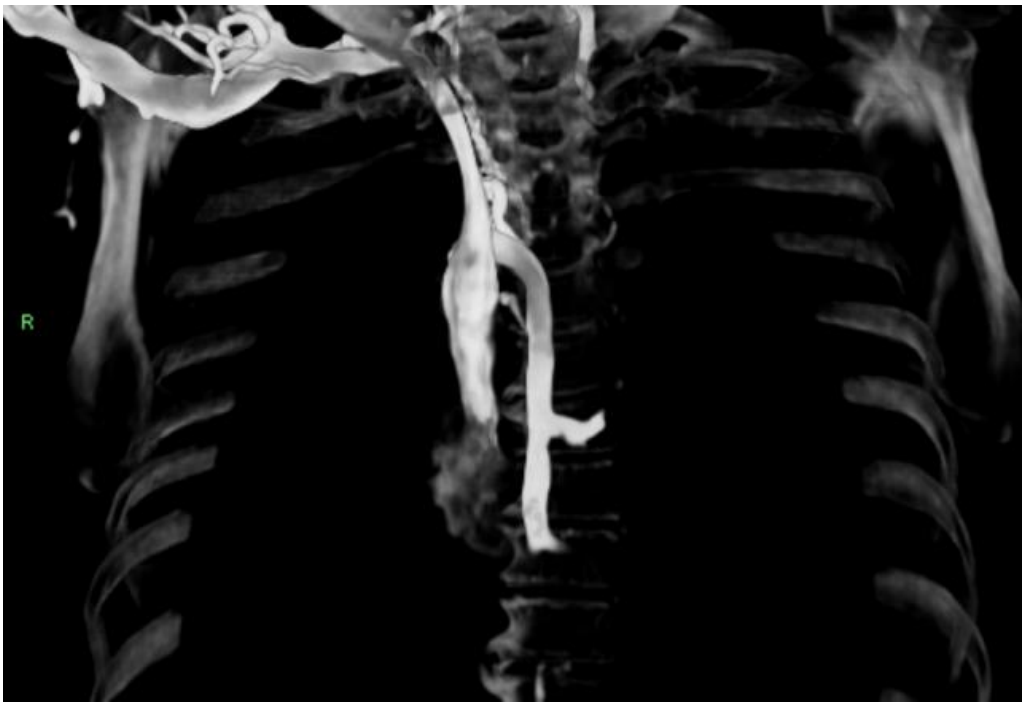


Figure K: ***RADIOGRAPHIC IMAGE SHOWING THE AZYGOS VEIN AND ITS TERMINATION INTO THE SUPERIOR VENACAVA***

of the specimen.

Gesase AP (2008) [28] study observes a case of azygos vein dividing into right and left roots and joining the right and the left superior vena cava.

Lydia S Quadros et al (2009) [3] study observes absence of accessory hemiazygos vein. The left posterior intercostal veins (4th, 5th, 6th and 7th) drain directly into the azygos vein. Right ascending lumbar vein forms the azygos vein and the left ascending lumbar vein forms the hemiazygos vein. The hemiazygos vein is not developed fully.
Very rarely the azygos vein may drain into the left superior vena cava. One such variation has been noted by Uemura et al. (2009).[77]

Kutoglu et al (2012) [71] classifies the specimens in Anson's system as the primitive or embryological types, transient type, unicolon type (three basic types) and eleven subgroups. Among the 48 cadavers, 2.1 % belongs to Type I, 91.7% is Type II, and 2.1% is Type III and 4.2% is atypic.
Of those classified as Type II, 27.1% is Group 2, 2.1% is Group 3, 10.4% is Group 4, 10.4% is Group 5, 8.3% is Group 6A, 8.3% is Group 6B, 22.9% is Group 7, and 2.1% is Group 9.

According to Seema (2012) a continuous left azygos vein with no transvertebral connection with the right azygos vein is noted [60]. Aortic nipple enlargement is also seen. During development longitudinal channels

develop on both sides and are present posterolateral to the aorta. The subcentral vein connects these azygos line veins. The presence of left azygos vein that is continuous with no transvertebral connection with the right azygos vein can be due to the non-formation of subcentral veins and the persistence of the left azygos line [80] (Williams et al., 1995)

Suat keskin et al (2013) study [70] observes Type 1 anomaly. Independent right and left azygos veins with hemiazygos vein absence are present. The right azygos vein terminates in the superior venacava. There is no hemiazygos vein and the left azygos vein terminates in the left subclavian vein.

Younghee Yim, et al (2014) observes absence of azygos vein congenitally. Left superior venacava is present. Hemiazygos vein is dilated and terminates into the left superior vencava through prominent left superior intercostal vein. [82].

According to Sara Piciucchi et al (2014) non-development of superior segment of the right supracardinal vein results in absence of the azygos vein [58].

The retro oesophageal pouch on the right side noted to as the space of Holzkneckt has importance to radiologic interpretation (Lachman). When descending aorta, which is elongated, buckles into lower chest the

azygoesophageal recess is compromised significantly at the lower extent. This may be misinterpreted as right inferior mediatinal mass lesion.

EMBRYOLOGY

The azygos system of veins is a paired paravertebral venous pathway in the posterior aspect of thorax. The embryology of the azygos–hemiazygos system is complex and controversial.

Embryologically, the azygos vein is considered to develop from the upper right supracardinal vein. The azygos arch develops from the upper segment of the right posterior cardinal vein [80]

The 4^{th} to 11^{th} right intercostal veins end in the right supra cardinal vein. This with a portion of right posterior cardinal vein develops into the azygos vein. The 4^{th} to 11^{th} left intercostal veins end in the left supra cardinal vein. This develops into the hemiazygos vein that ends into the azygos vein [68]

The right supra cardinal vein develops into the azygos vein and the left supra cardinal vein develops into the hemiazygos vein. A transverse communication is formed between them at sixth and seventh thoracic vertebrae in adults. At the left side, upper part of this anastomosis remains as accessory hemiazygos vein. Absence of accessory hemiazygos vein may be due to congenital regression of the left supra cardinal vein. In this condition the left posterior intercostal veins (4th, 5th, 6th and 7th) drain into the azygos vein. [12,40,71] (Caggiati, Kocabyyyk, Kutoglu).

Anson and McVay describe three types of azygos systems of veins with

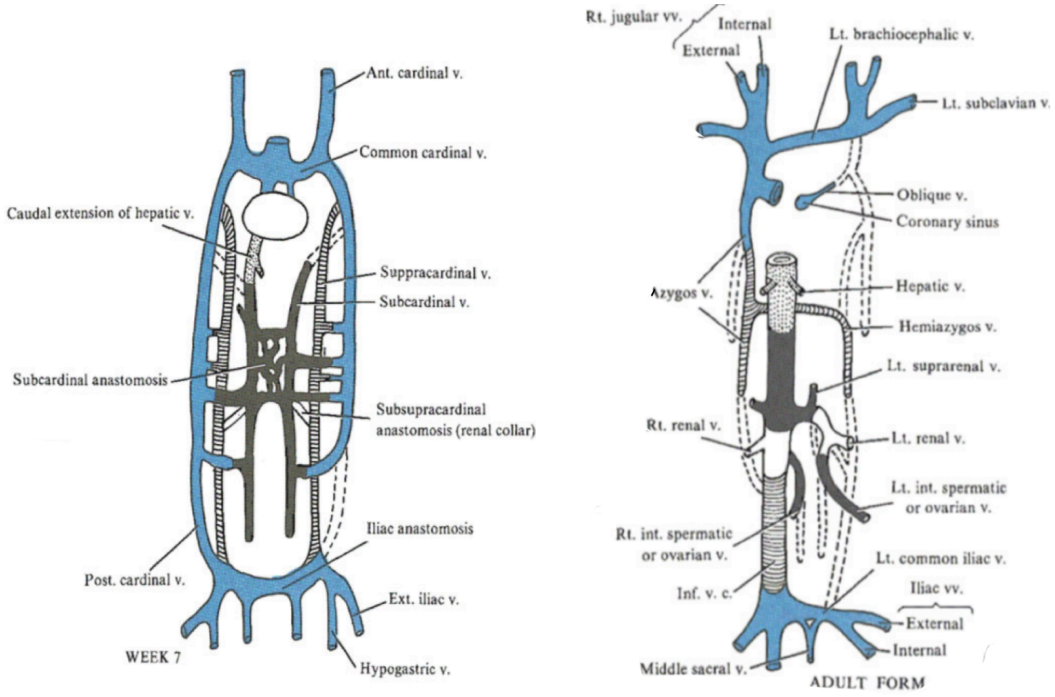


***Figure L:* DEVELOPMENT OF THE AZYGOS SYSTEM OF VEINS**

subgroups. Many differences are present because of variations in the closure and division of longitudinal and horizontal veins that develop in the embryo. Because of this many combinations occur. Type I anomaly may result due to absence of subcardinal veins and persistence of left azygos line. It consists of two separate veins running parallel in the posterior mediastinum. They are an azygos vein on the right and superior and inferior azygos veins that form a single vein, on the left.

Development of an azygos lobe is a controversial topic. It has been attributed to the posterior cardinal vein failing to migrate over the apex of the right lung. This results in the vein indenting the lung [19,20] (Dudiack).

In the development of this condition there are two variable factors. They are the growing lung buds and the growing cardinal veins. The posterior cardinal vein arches forwards to join the common cardinal vein. It brings with it a fold of primitive pleural membrane, by which the apex is divided into medial and lateral compartment. The lung bud grows upwards and outwards. It passes usually lateral to the vein. The vein is drawn downwards and inwards with the descent of heart. If there is a slight variation in the position of these factors, the vein too lateral or a lung bud not lateral enough, the pleural fold would press against the lung. Then a medial process is split, which expands upward as the accessory lobe.

The variation in the formation of the azygos vein can be explained on the developmental basis. The persistence of subcentral veins which are the temporary veins lying posterior to primitive dorsal aorta form the plexiform veins, the medial root. The right lumbar azygos vein which develop from the right azygos line vein forms the intermediate root. This right azygos line vein communicates at the lower end with subcardinal vein that give rise to renal segment of the inferior vena cava. The lateral root of the azygos is formed by the combination of the right subcostal vein and right ascending lumbar vein. The right subcostal vein develops from the right 12th thoracic segmental vein. The right ascending lumbar vein develops from the supra cardinal vein (thoracolumbar vein). So the presence of the vein that has to disappear as well as disappearance of vein that has to be present results in the anomalies of azygos vein formation[67] .

During development, the intermediate segment of the right supra cardinal vein joins the azygos or hemiazygos veins and the inferior venacava. Then this segment normally regresses. When the inferior venacava is absent, the azygos vein can become as large as the inferior venacava that it has replaced (Standring Grays, , T.W. Sadler Langmans) [67,72]

The development of a preaortic azygos vein may be explained developmentally. The subcentral veins develop on the posterior aspect of the aorta and connect the left and right venous lines [80] (Williams Grays).

There may be abnormal communication between the left intersegmental veins and the azygos venous lines on the anterior aspect of the aorta. This can be without the involvement of subcentral veins. [56] (Ozbeck).

MATERIALS AND METHODS

A total of 50 specimens were analyzed. Azygos system of veins were exposed in 30 embalmed adult human cadavers by dissection method in Anatomy Department, Stanley Medical College and analyzed. 20 radiologic images from CTPA- computerized tomography pulmonary angiogram obtained from Department of Radiology, Stanley Medical College were analyzed for azygos system of veins.

1) DISSECTION METHOD

This study was done in Anatomy Department of Stanley Medical College on 30 conserved human cadavers irrespective of their sex. The cadavers were examined between the years 2013 and 2015.The guidelines of Cunningham's manual of practical anatomy were followed.

The anterior thoracic wall was removed. The pericardium, heart, lungs were removed exposing the posterior intercostal veins. The right posterior intercostal veins were followed to trace the azygos vein. The hemiazygos vein and accessory hemiazygos vein were traced by following the course of left posterior intercostal veins. Thoracic aorta and oesophagus removal was done. Then the azygos system of veins was exposed by blunt dissection of the parietal pleura. The anterior abdominal wall was also removed with its parietal peritoneum. The abdominal organs were removed. The ascending

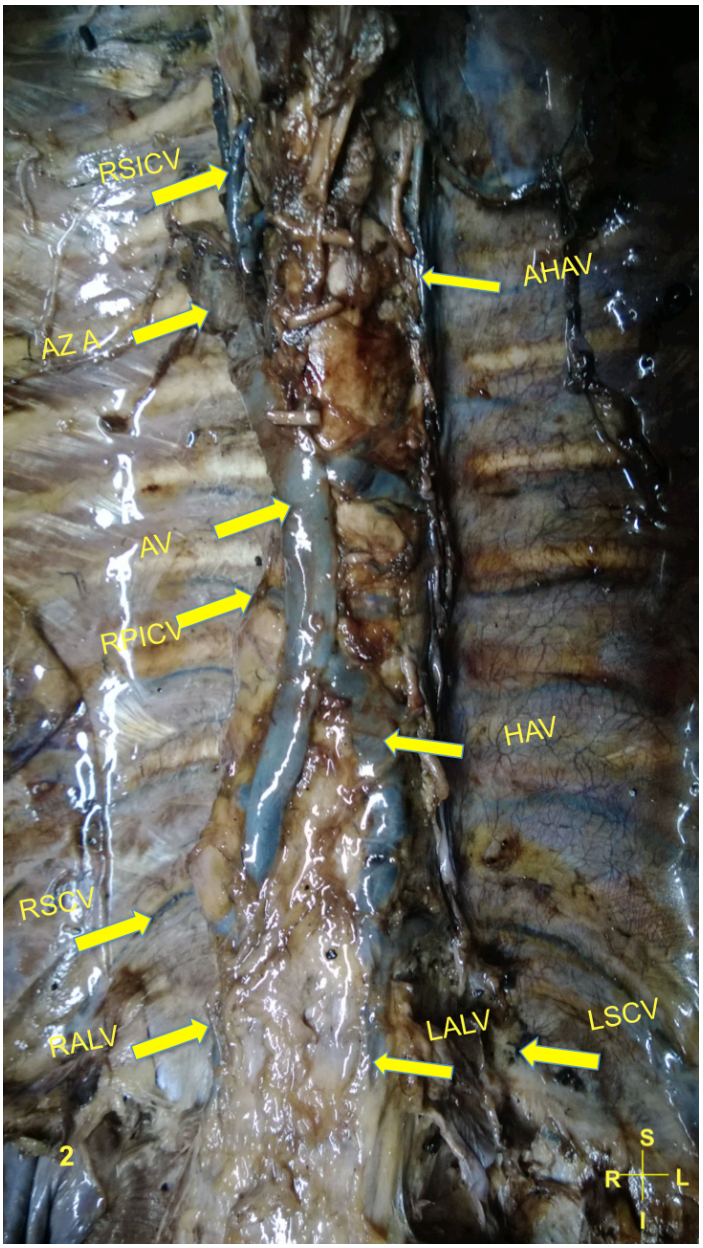


Figure 1: CADAVERIC SPECIMEN SHOWING AZYGOS VENOUS SYSTEM. ***AV- AZYGOS VEIN. AZ A- AZYGOS ARCH , HAV- HEMIAZYGOS VEIN, AHAV- ACCESSORY HEMIAZYGOS VEIN, RSICV- RIGHT SUPERIOR INTERCOSTAL VEIN, RSCV- RIGHT SUBCOSTAL VEIN, RALV- RIGHT ASCENDING LUMBAR VEIN, LSCV- LEFT SUBCOSTAL VEIN, LALV- LEFT ASCENDING LUMBAR VEIN, RPICV- RIGHT POSTERIOR INTERCOSTAL VEIN***

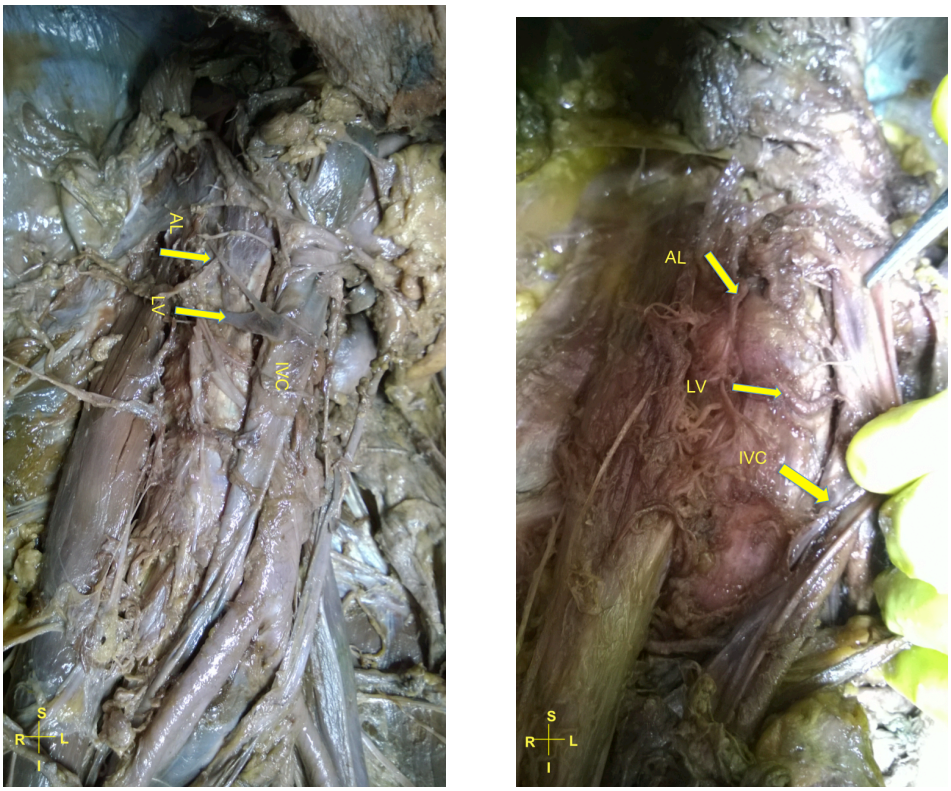


Figure 2 : SPECIMENS SHOWING ASCENDING LUMBAR VEINS*. AL- ASCENDING LUMBAR VEIN, LV- LUMBAR VEIN, IVC- INFERIOR VENACAVA*

Figure 3 : MEASUREMENT OF DIAMETER OF THE AZYGOS VEIN IN A CADAVERIC SPECIMEN

lumbar veins were exposed after elevation of the diaphragm. The photos of azygos venous system were taken and schematic representation done.

The following measurements [mm] were taken with a vernier caliper

(i) the compressed diameter of azygos vein just before its termination to the superior vena cava

(ii) the compressed diameter of hemiazygos vein just before its termination to the azygos vein.

The level of arching of the azygos vein, the termination levels of the azygos, hemiazygos, and accessory hemiazygos veins and the course of azygos vein in relation to midline of the vertebral column were noted.

The specimens were classified based on the study of Anson BJ and McVay CB [(5)]. Three main types of azygos system of veins (primitive or embryological), transition and single column types were evaluated based on the vertical and horizontal connections. They were further classified into 11 subtypes. Variations in the anatomy of azygos venous system were noted.

2) RADIOLOGICAL METHOD

Radiographic images 20 in number were obtained from Radiology Department, Stanley Medical College from who had undergone

Computerized tomography Pulmonary Angiogram (CTPA) for varied reasons between the years 2013 to 2015, performed by 128 slice Computerized tomography (CT) scan, slice thickness 0.6 mm, Omnipaque used as contrast.

The images of the azygos system of veins were visualized and the measurements made and analyzed. The patients with intrathoracic malignancies were excluded from the study. The parameters evaluated were the presence of a hemiazygos vein, accessory hemiazygos vein, the position of the azygos vein with reference to midline of the vertebral column and carina, and the diameter of the azygos, hemiazygos veins at the level of its termination to the superior vena cava and azygos vein respectively. Variations in the anatomy of the azygos system were also noted.

STATISTICAL ANALYSIS

The following statistical methods are applied. Descriptive statistical analysis had been carried out in the present study. Results on continuous measurements are presented as mean±SD (Min- Max) . Results on categorical measurements are presented in Number (%).

The mean, standard deviation was calculated for the compressed diameter at the termination of the azygos vein and hemiazygos vein. The data

obtained was recorded, analyzed and compared with that of previous studies.

OBSERVATION

MODE OF FORMATION OF THE AZYGOS VEIN

Among the 30 cadaver specimens studied, single root, the lateral root forms the azygos vein in 90% of the specimens (27 specimens).

Out of these in 67% (20 specimen) it is formed by right ascending lumbar vein and right subcostal vein and in 23% (7 specimen) only by the right subcostal vein. In specimens numbered 6, 8,16,18,26,27 and 28 the azygos vein is formed from only the right subcostal vein.

In 7% (2 specimens) azygos vein is formed by two roots, lateral (right subcostal and right ascending lumbar veins) and intermediate root (lumbar azygos veins). In the specimens numbered 7 and 23 the lateral and intermediate roots form the azygos vein. In 3% (1 specimen) the azygos vein is formed by all the three roots. This is seen in specimen numbered 10.

Chart 1 depicts the mode of formation of the azygos vein.

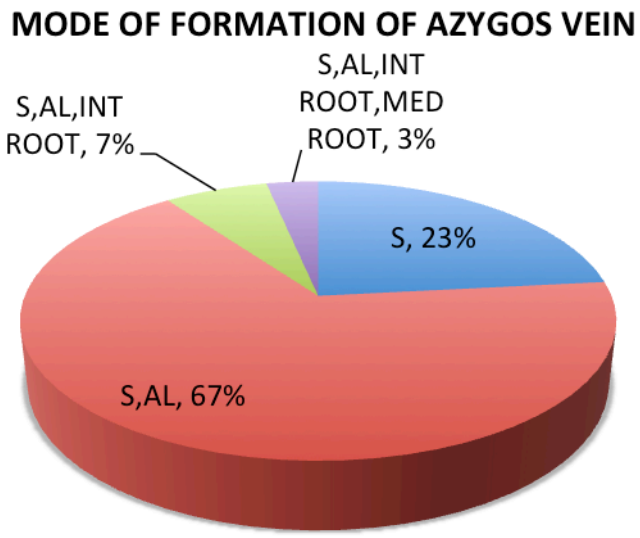


***Chart1:** THE MODE OF FORMATION OF THE AZYGOS VEIN ,S- Right Subcostal vein, AL- Right Ascending lumbar vein, MED ROOT- Medial root, INT ROOT- Intermediate root*

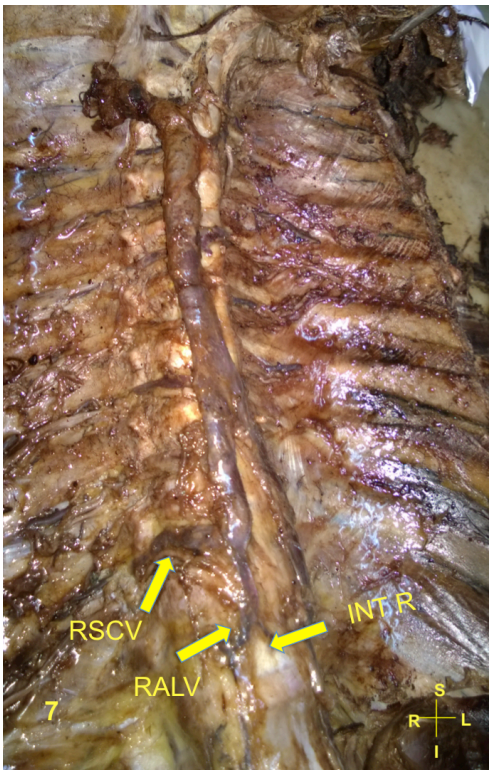


Figure 4: MODE OF FORMATION OF THE AZYGOS VEIN FROM LATERAL AND INTERMEDIATE ROOTS. ***RSCV- RIGHT SUBCOSTAL VEIN, RALV- RIGHT ASCENDING LUMBAR VEIN, INT R- INTERMEDIATE ROOT.***

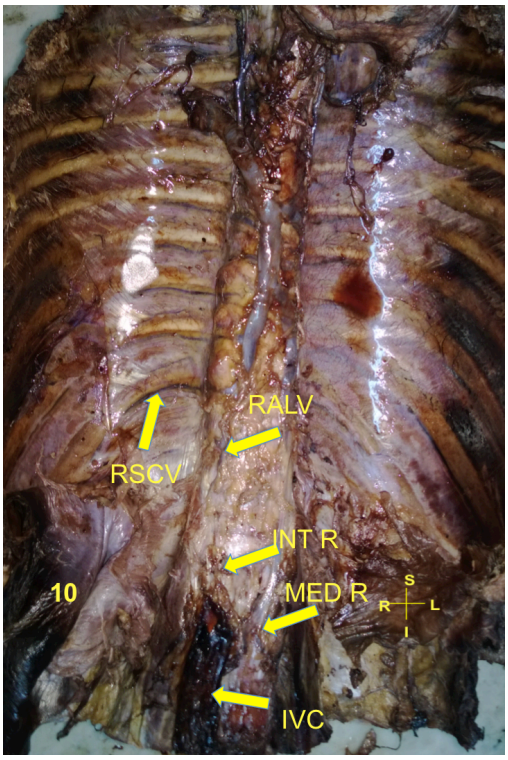


Figure 5: MODE OF FORMATION OF THE AZYGOS VEIN FROM MEDIAL, INTERMEDIATE AND LATERAL ROOTS, ***RSCV- RIGHT SUBCOSTAL VEIN, RALV- RIGHT ASCENDING LUMBAR VEIN, IVC- INFERIOR VENA CAVA, INT R- INTERMEDIATE ROOT, MED R- MEDIAL ROOT***

COURSE OF THE AZYGOS VEIN IN RELATION TO MIDLINE OF THE VERTEBRAL COLUMN

Among the 50 specimens, azygos vein is present to the right of midline of the vertebral column in 62% (31 specimens), to the left in 22%(11 specimens) and in the midline in 16% (8 specimens). Chart 2 shows the relation of the azygos vein to midline of the vertebral column.

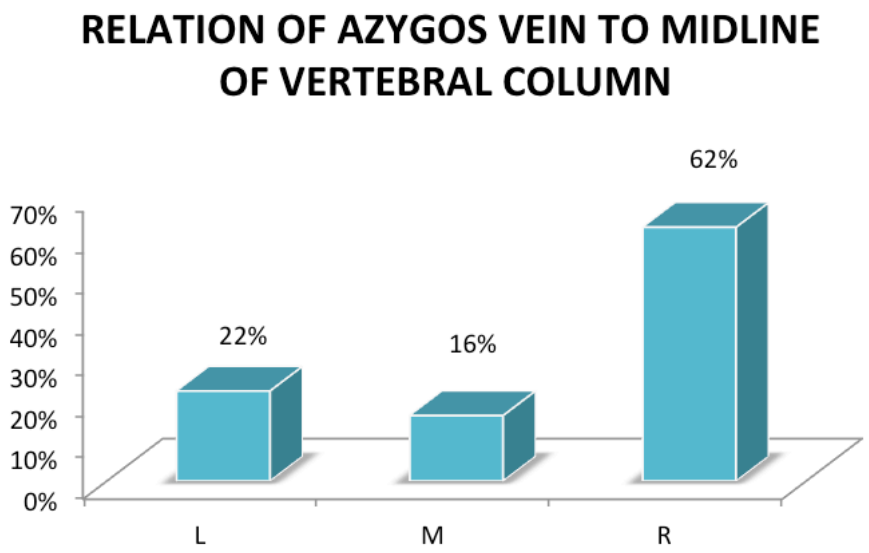


Chart 2: RELATION OF THE AZYGOS VEIN TO MIDLINE OF THE VERTEBRAL COLUMN, M-Midline, L- Left, R- Right

Figure 6: SPECIMEN SHOWING THE AZYGOS VEIN COURSE, ON THE MIDLINE OF THE VERTEBRAL COLUMN

Figure 7: SPECIMEN SHOWING THE AZYGOS VEIN COURSE ON THE LEFT OF THE MIDLINE OF THE VERTEBRAL COLUMN

Figure 8: SPECIMEN SHOWING THE AZYGOS VEIN COURSE ON THE RIGHT OF THE MIDLINE OF THE VERTEBRAL COLUMN

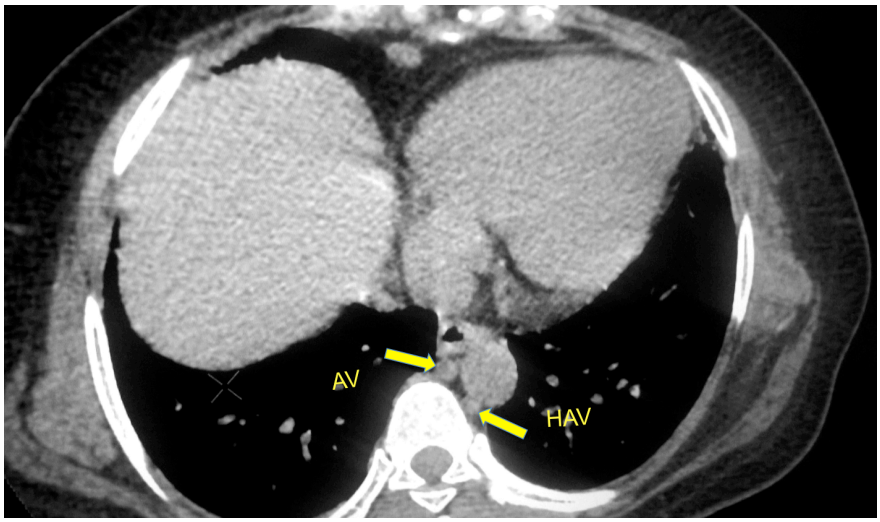


Figure 9: ***RADIOGRAPHIC IMAGE, SPECIMEN SHOWING THE AZYGOS VEIN COURSE TO THE LEFT OF THE MIDLINE OF THE VERTEBRAL COLUMN, CT AXIAL VIEW,*** ***AV- AZYGOS VEIN, HAV- HEMIAZYGOS VEIN***

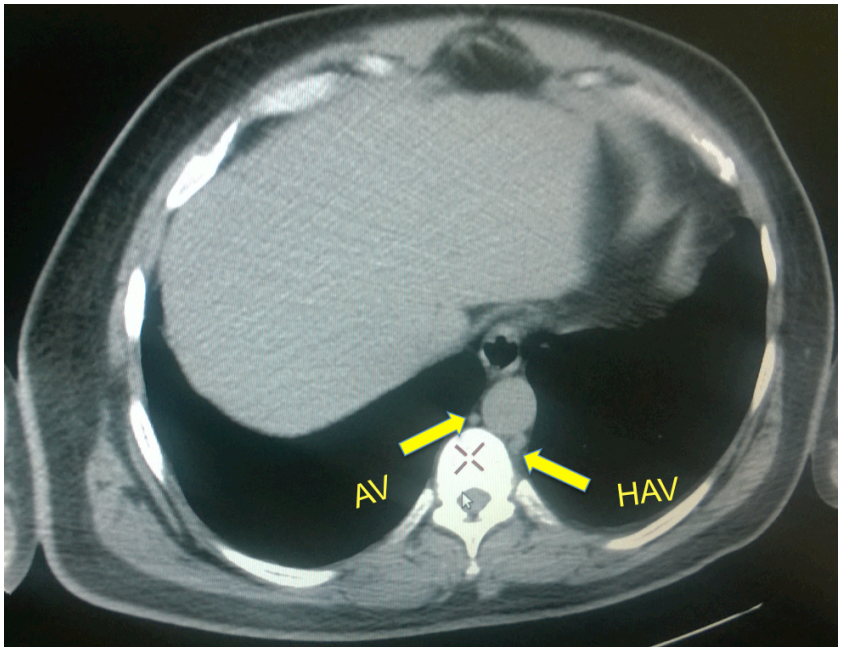


Figure 10: ***RADIOGRAPHIC IMAGE, SPECIMEN SHOWING THE AZYGOS VEIN COURSE ON THE MIDLINE OF THE VERTEBRAL COLUMN, CT AXIAL VIEW,*** ***AV- AZYGOS VEIN , HAV- HEMIAZYGOS VEIN***

LEVEL OF ARCHING OF THE AZYGOS VEIN AND LEVEL OF TERMINATION INTO THE SUPERIOR VENACAVA

Out of 50 specimens studied, the level of arching of the azygos vein is at the fourth thoracic vertebral level in 48% (24 specimens), fifth thoracic vertebral level in 38% (19 specimens) and sixth thoracic vertebral level in 14% (7 specimens). The level of termination of azygos vein into superior venacava is at fourth thoracic vertebral level in 64 % (32 specimens), fifth thoracic vertebral level in 20% (10 specimens), third thoracic vertebral level in 12% (6 specimens) and at sixth thoracic vertebral level level in 4% (2 specimens).

Azygos lobe is noted in the right lung in one radiologic specimen.

Table 1 gives the vertebral levels of azygos vein termination and their percentages. Charts 3 and 4 show the level of arching of the azygos vein and the level of termination into superior vencava respectively.

LEVELS	FREQUENCY	%	VALID %
T3	6	12	12
T4	32	64	64
T5	10	20	20
T6	2	4	4
TOTAL	**50**	**100**	**100**

TABLE 1: TERMINATION LEVELS OF THE AZYGOS VEIN

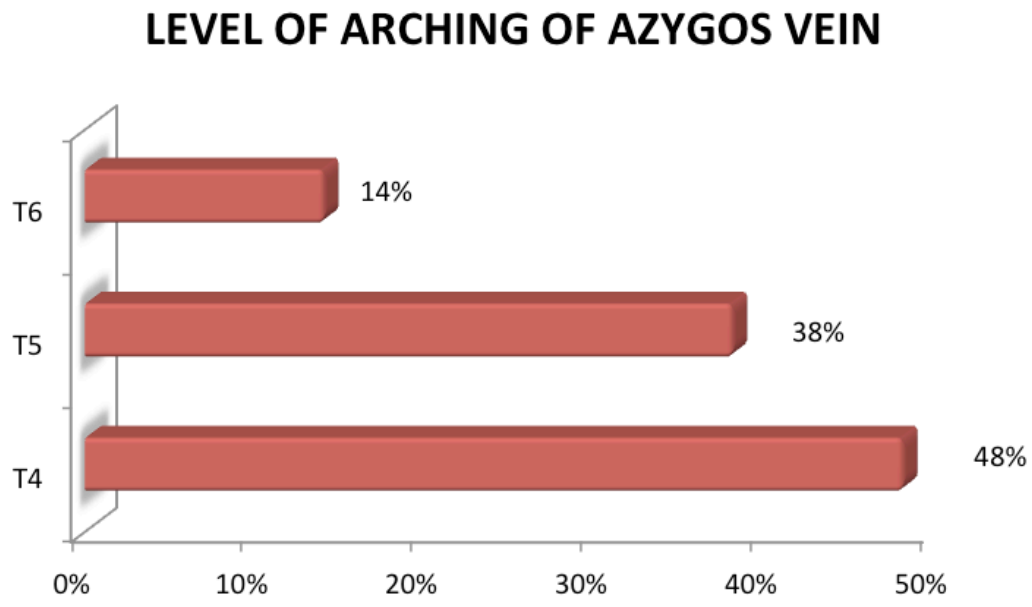


Chart 3: THE LEVEL OF ARCHING OF THE AZYGOS VEIN, T4, T5, T6- Vertebral levels

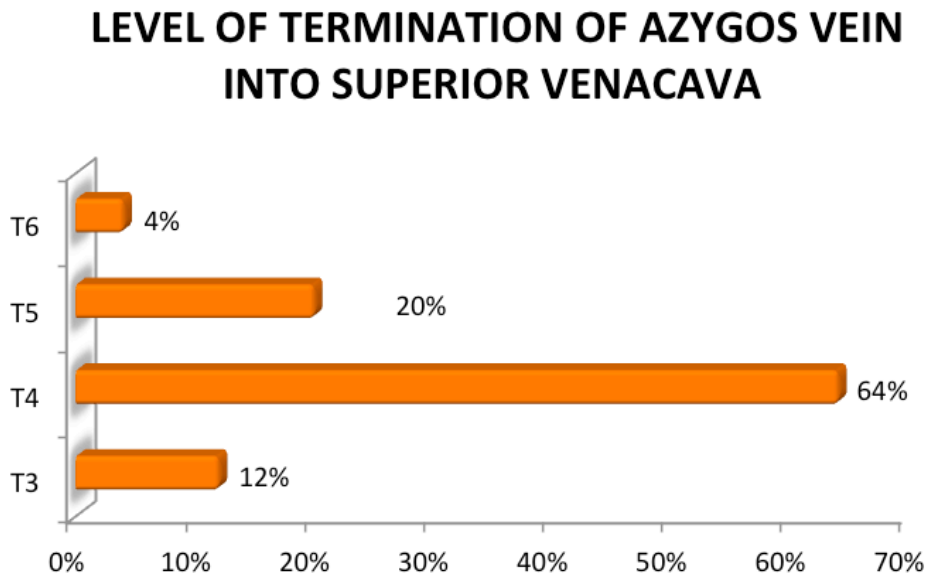


Chart4: THE LEVEL OF TERMINATION OF THE AZYGOS VEIN INTO THE SUPERIOR VENACAVA, T3,T4, T5,T6- Vertebral levels

Figure 11: SPECIMEN IN WHICH THE ARCH OF THE AZYGOS VEIN AND THE TRACHEAL BIFURCATION SHOWN, AV ARCH- AZYGOS VEIN ARCH, TR BI-TRACHEAL BIFURCATION

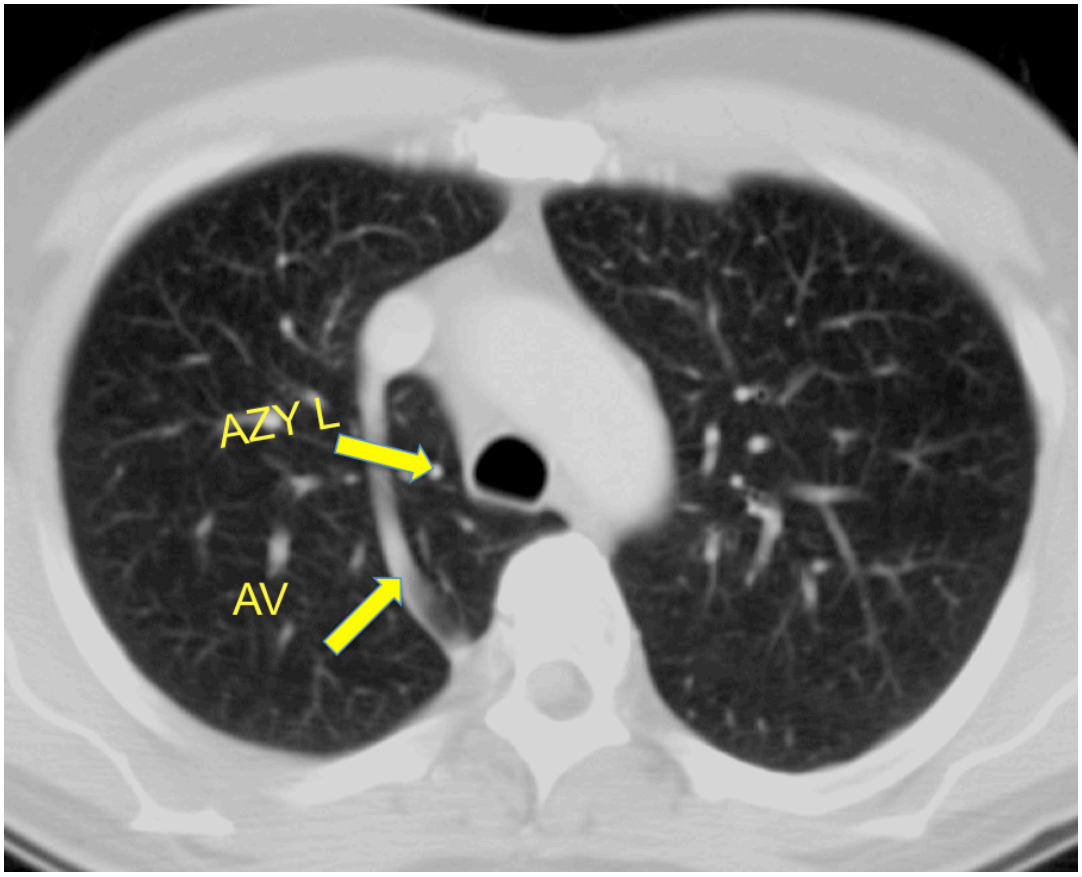


Figure 12: RADIOGRAPHIC IMAGE, SPECIMEN SHOWING AZYGOS LOBE, CT AXIAL VIEW, AV-AZYGOS VEIN, AZY L- AZYGOS LOBE

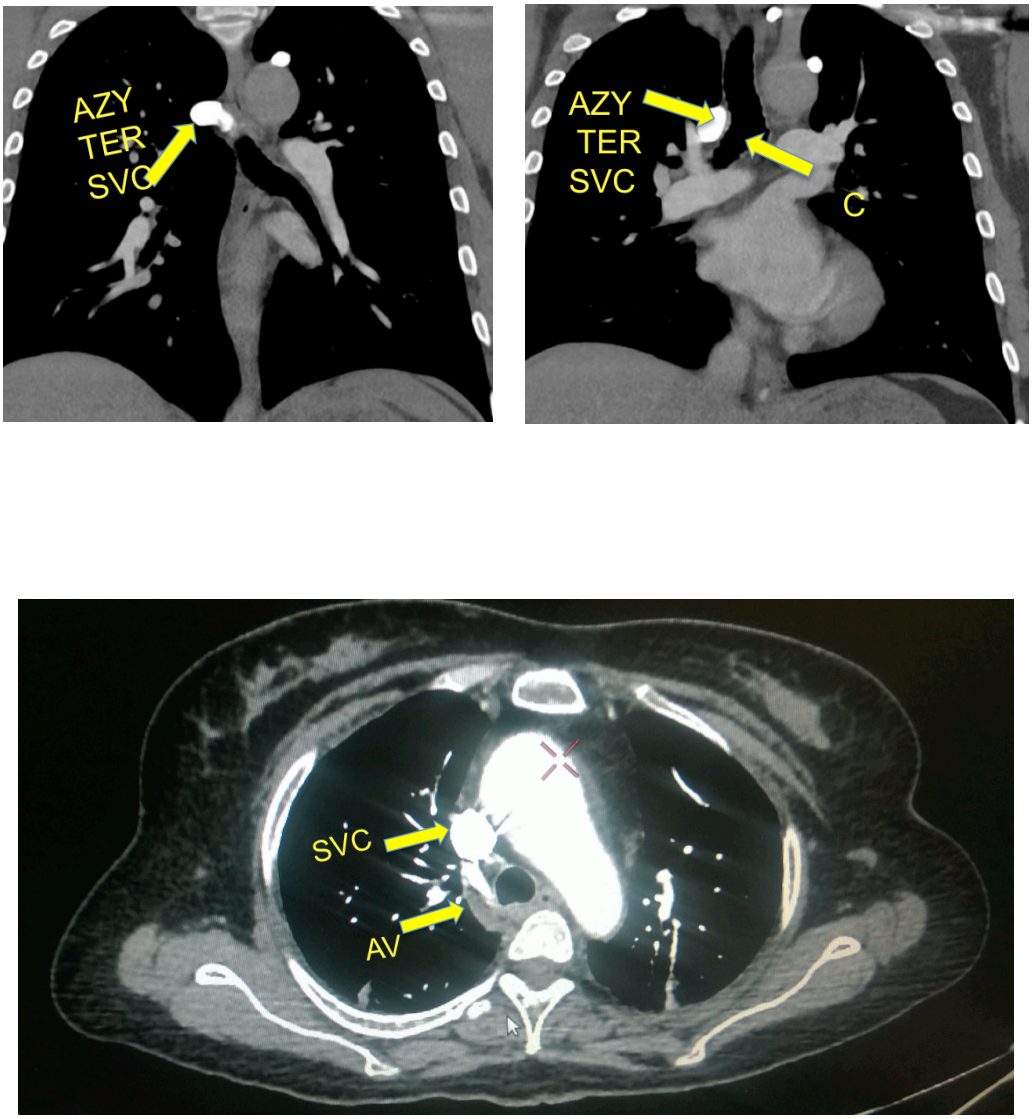


Figure 13: ***RADIOGRAPHIC IMAGE, SPECIMEN SHOWING THE TERMINATION OF AZYGOS VEIN INTO SUPERIOR VENCAVA, CT CORONAL AND AXIAL VIEW,*** *ACCESSORY HEMIAZYGOS VEIN WAS ABSENT IN THE SPECIMEN, AV- AZYGOS VEIN, SVC- SUPERIOR VENCAVA, C- CARINA, AZY TER SVC- AZYGOS VEIN TERMINATING INTO SUPERIOR VENACAVA*

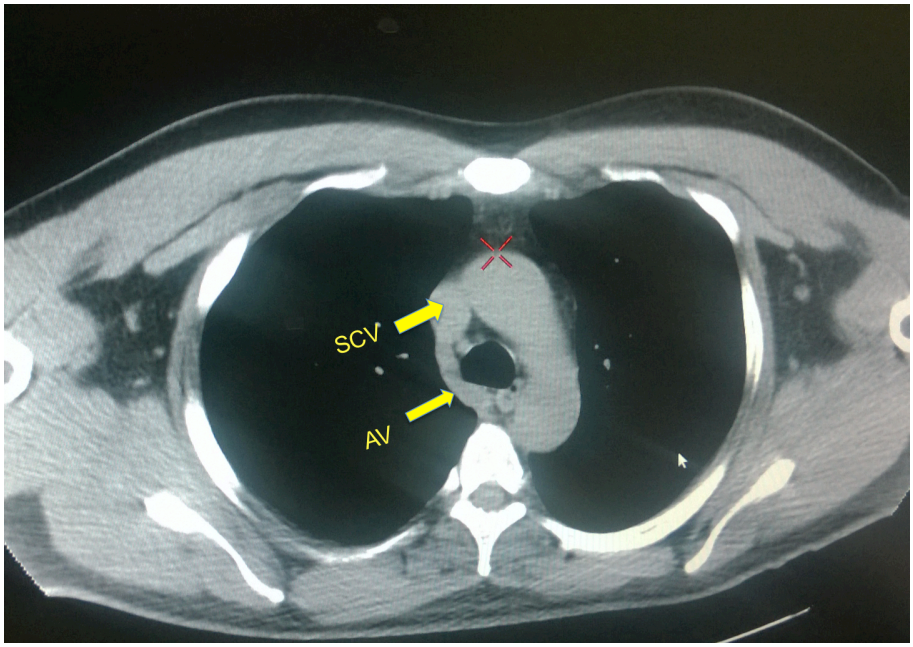


Figure 14: ***RADIOGRAPHIC IMAGE, SPECIMEN SHOWING THE TERMINATION OF THE AZYGOS VEIN INTO THE SUPERIOR VENCAVA, CT CORONAL AND AXIAL VIEW,*** ***AV-AZYGOS VEIN, SVC- SUPERIOR VENCAVA, AZY TER-AZYGOS VEIN TERMINATION INTO SUPERIOR VENACAVA.***

LEVEL OF TERMINATION OF THE HEMIAZYGOS AND THE ACCESSORY HEMIAZYGOS VEIN

Among the 50 specimens analyzed, hemiazygos vein is absent in 7 specimens. In the cadaveric specimens it is absent in specimens numbered 6, 14, 26 and 29. In three radiologic specimens also hemiazygos vein is absent making it to a total of seven. In total hemiazygos vein is absent in 14% of the specimens.

Chart 5 depicts the percentage of hemiazygos vein in the specimen.

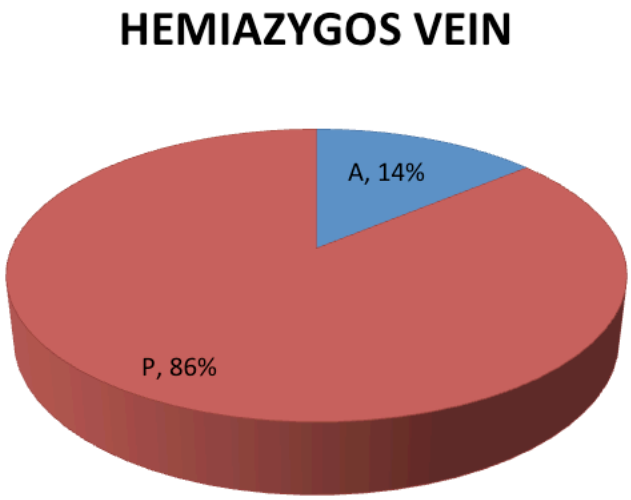


Chart 5: THE PERCENTAGE OF THE HEMIAZYGOS VEIN IN THE SPECIMENS, A-Absent, P-Present

Out of 43 specimens in which it is present, level of termination of the hemiazygos vein is at eighth thoracic vertebral level in 39.5 % (17 specimens), ninth thoracic vertebral level in 39.5 % (17 specimens), seventh thoracic vertebral level in 14% (6 specimens) and at tenth thoracic vertebral level in 7% (3 specimens).

Termination levels of the hemiazygos vein and their percentages are shown in table 2. Chart 6 depicts the level of termination of hemiazygos vein into the azygos vein.

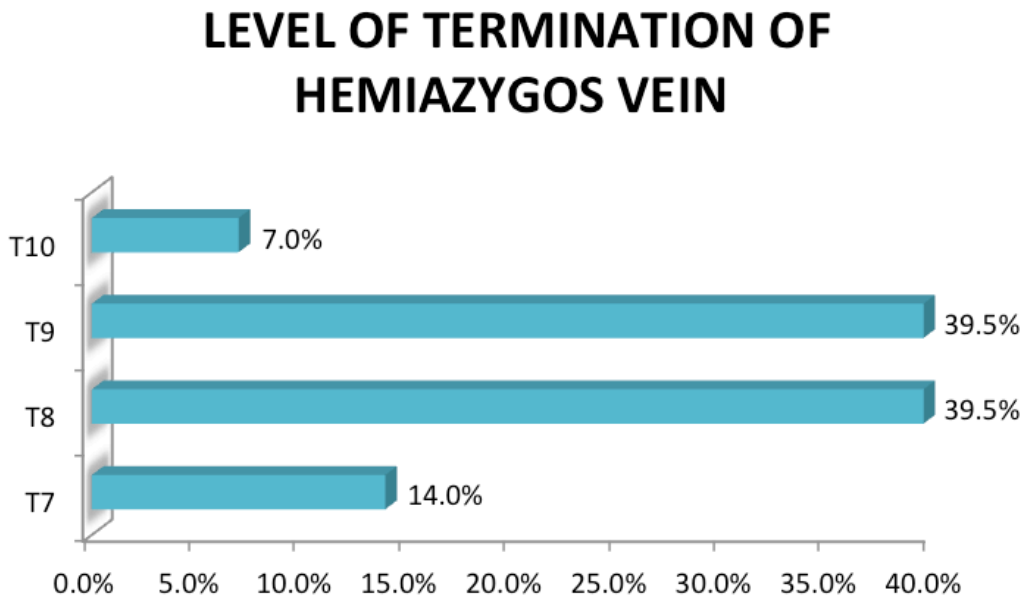


***Chart 6:** LEVEL OF TERMINATION OF THE HEMIAZYGOS VEIN, T7, T8, T9, T10 - Vertebral levels*

	VERTEBRAL LEVELS	FREQUENCY	%	VALID %
	T7	6	12	14
	T8	17	34	39.5
	T9	17	34	39.5
	T10	3	6	7
	TOTAL	**43**	**86**	**100**
MISSING	-	-7	14	
	TOTAL	**50**	**100**	

TABLE 2: TERMINATION LEVELS OF THE HEMIAZYGOS VEIN

Among the 50 specimens analyzed the accessory hemiazygos vein is absent in 14 specimens (28%).

Among the 30 cadaveric specimens, the accessory hemiazygos vein is absent in 6 specimens. It is absent in cadaveric specimens numbered 6,12,14, 18,23 and 29. In eight radiologic specimens also it is absent.

Chart 7 depicts the percentage of accessory hemiazygos vein in the specimens.

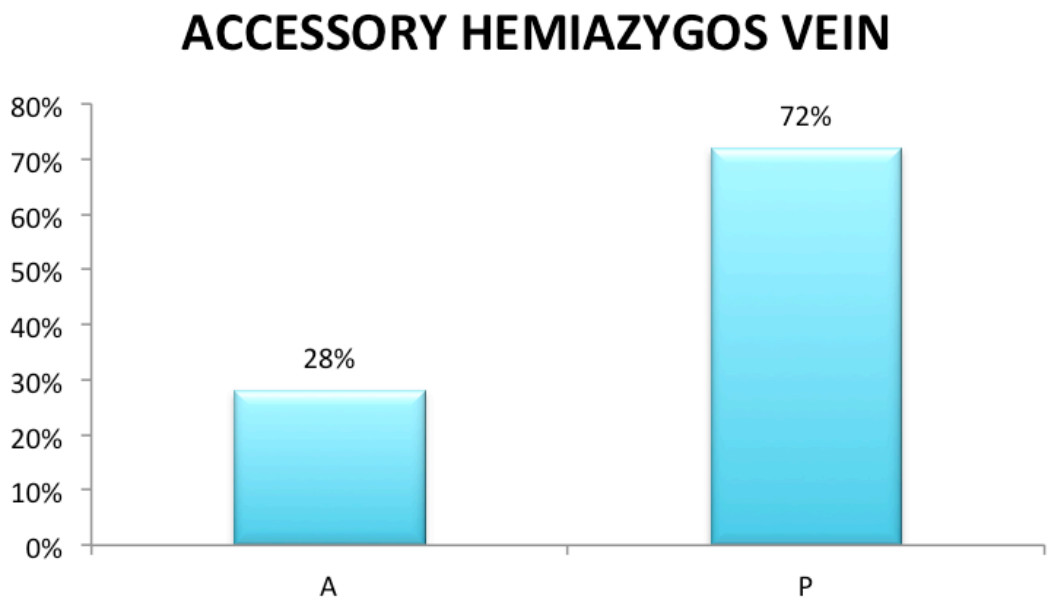


Chart 7: PERCENTAGE OF THE ACCESSORY HEMIAZYGOS VEIN IN THE SPECIMENS, A- Absent, P-Present

Out of the 24 cadaveric specimens in which it is present, level of termination of the accessory hemiazygos vein is at sixth thoracic vertebral level in 42 % (10 specimens), seventh thoracic vertebral level in 33% (8 specimens), ninth thoracic vertebral level in 17% (4 specimens), eighth thoracic vertebral level in 4%(1specimen) and at fifth thoracic vertebral level in 4% (1 specimen).

Table 3 gives the termination levels of accessory hemiazygos vein and their percentages in the cadaveric specimens. Chart 8 depicts the level of termination of accessory hemiazygos vein into the azygos vein in the cadaveric specimens.

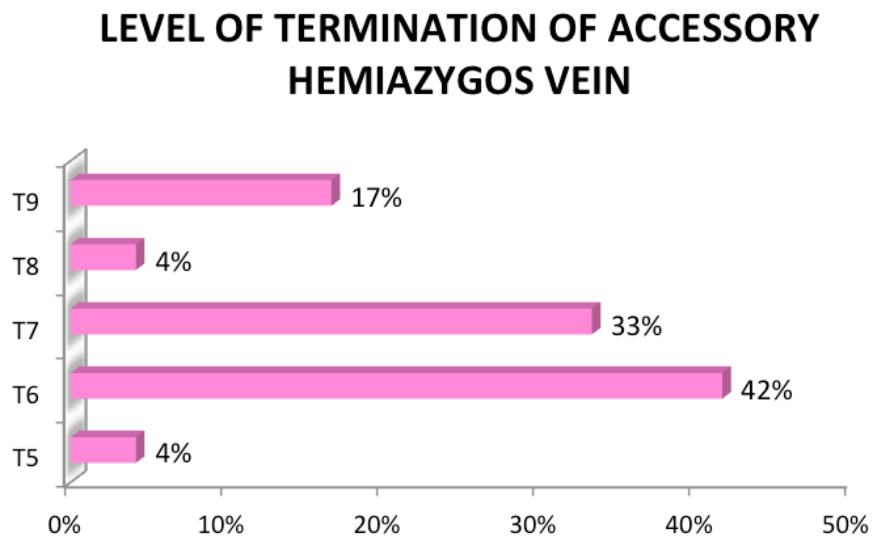


Chart 8: THE LEVEL OF TERMINATION OF THE ACCESSORY HEMIAZYGOS VEIN, T5, T6, T7, T8, T9 Vertebral levels

	VERTEBRAL LEVELS	FREQUENCY	%	VALID %
	T5	1	3.5	4
	T6	10	33	42
	T7	8	27	33
	T8	1	3.5	4
	T9	4	13	17
	TOTAL	**24**	**80**	**100**
MISSING	-	-6	20	
	TOTAL	**30**	**100**	

TABLE3 3: TERMINATION LEVELS OF THE ACCESSORY HEMIAZYGOS VEIN

Figure 15: SPECIMEN IN, WHICH THE HEMIAZYGOS AND THE ACCESSORY HEMIAZYGOS VEIN ARE ABSENT

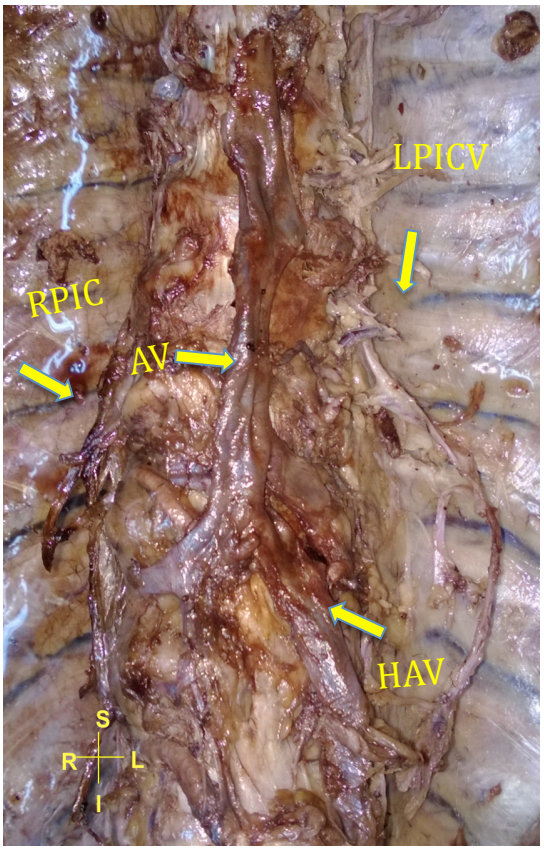


Figure 16: SPECIMEN IN, WHICH THE ACCESSORY HEMIAZYGOS VEIN IS ABSENT,AV-AZYGOS VEIN,HAV- HEMIAZYGOS VEIN, RPICV- RIGHT POSTERIOR INTERCOSTAL VEIN, LPICV-LEFT POSTERIOR INTERCOSTAL VEIN

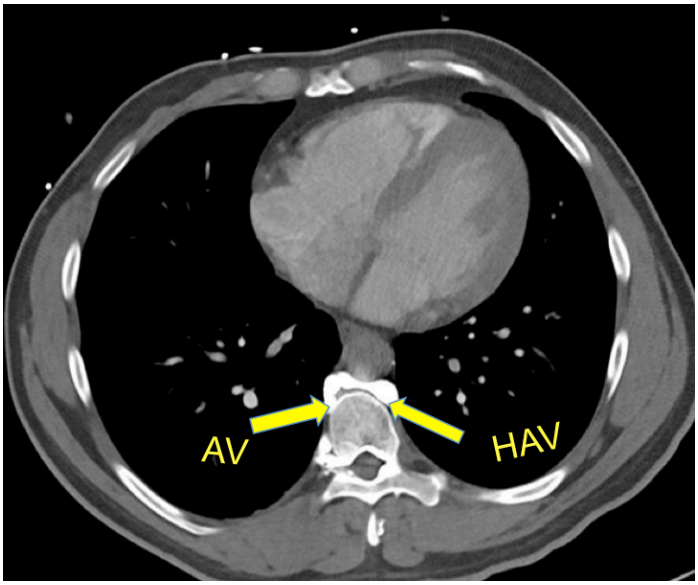
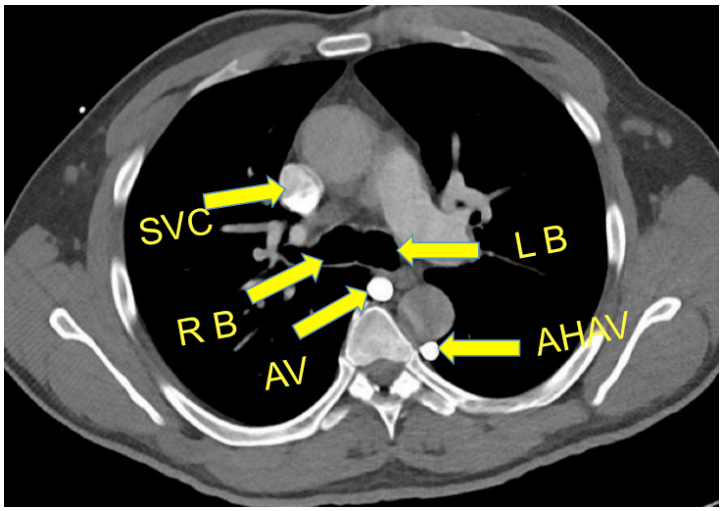
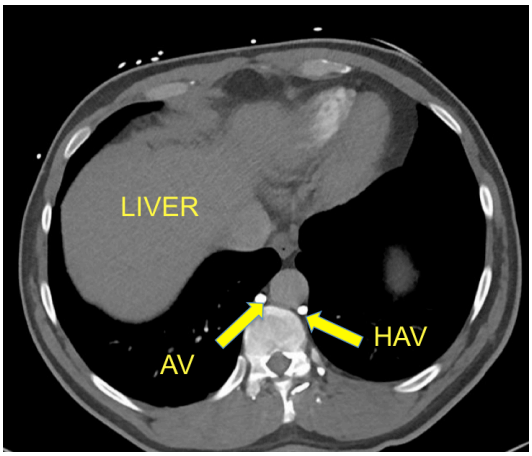


Figure 17: RADIOGRAPHIC IMAGE, SPECIMEN SHOWING COMMUNICATION BETWEEN THE AZYGOS AND THE HEMIAZYGOS VEIN, CT AXIAL VIEW, AV-AZYGOS VEIN, HAV- HEMIAZYGOS VEIN





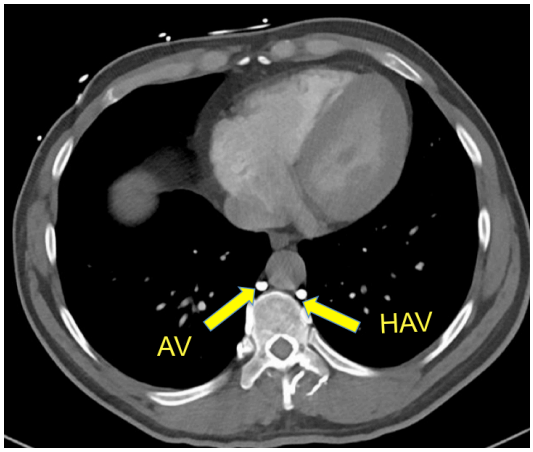


Figure 18: ***RADIOGRAPHIC IMAGE, SPECIMEN SHOWING AZYGOS, HEMIAZYGOS AND ACCESSORY HEMIAZYGOS VEINS AT VARIOUS LEVELS, CT AXIAL VIEW,*** ***AV- AZYGOS VEIN, HAV- HEMIAZYGOS VEIN, AHAV- ACCESSORY HEMIAZYGOS VEIN, SVC- SUPERIOR VENACAVA, RB- RIGHT PRINCIPAL BRONCHUS, LB- LEFT PRINCIPAL BRONCHUS***

DIAMETER OF THE AZYGOS AND THE HEMIAZYGOS VEINS AT THE LEVEL OF TERMINATION

Azygos vein diameter just at the termination into the superior vena cava is between 3.1 mm and 12.6 mm. The mean diameter is 6.9 +/-2.1mm. Hemiazygos vein diameter at the termination into the azygos vein is between 3.2 mm and 8.6 mm. The mean diameter is 5.05+/-1.3 mm.

Table 4 gives the descriptive statistical analysis of diameter of azygos and hemiazygos vein at their termination. Charts 9 and 10 depict the statistical analysis of the diameter of the azygos and the hemiazygos veins at their termination and charts 11 (a) and 11 (b) shows the comparison of the data of the diameter of azygos and hemiazygos veins at their termination.

	DAVT	DHAVT
N	50	43
RANGE	9.5	5.4
MIN	3.1	3.2
MAX	12.6	8.6
MEAN	**6.944**	**5.052**
STD DEV	2.064	1.325

***TABLE 4: DESCRIPTIVE STATISTICS**, DAVT- DIAMETER OF AZYGOS VEIN AT ITS TERMINATION, DHAVT- DIAMETER OF HEMIAZYGOS VEIN AT ITS TERMINATION, MIN- MINIMUM, MAX- MAXIMUM, STD DEV- STANDARD DEVIATION.*

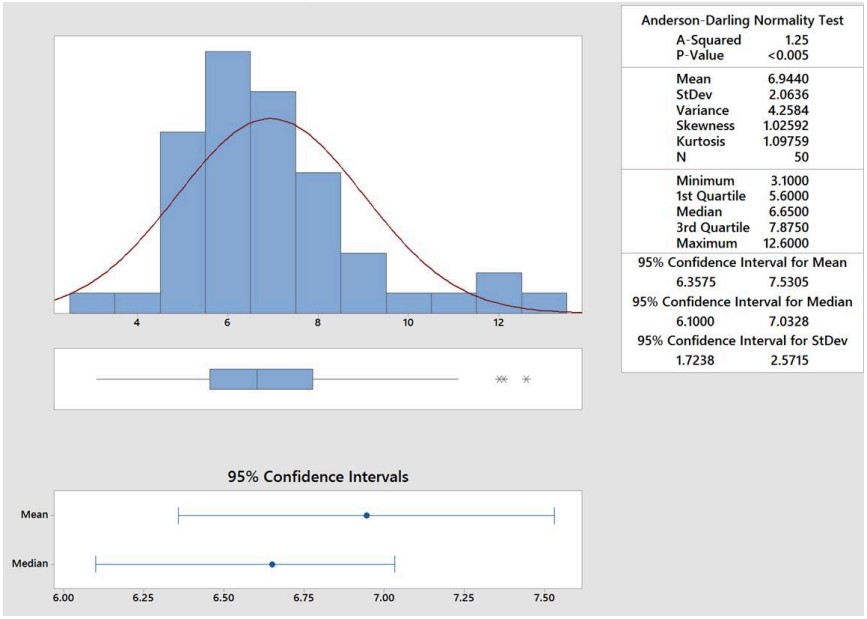


Chart 9: THE STATISTICAL ANALYSIS OF THE DIAMETER OF AZYGOS VEIN AT ITS TERMINATION INTO THE SUPERIOR VENACAVA

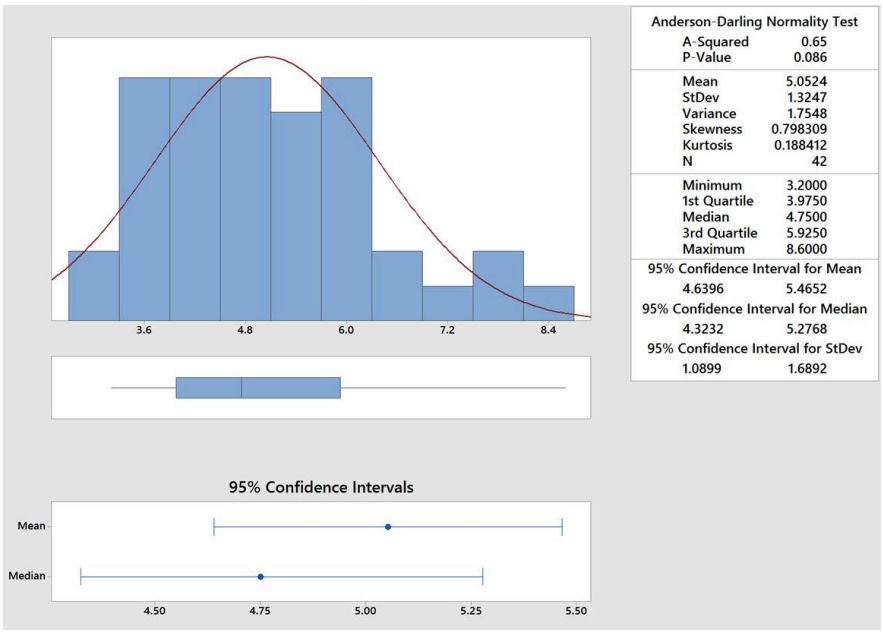


Chart 10: THE STATISTICAL ANALYSIS OF THE DIAMETER OF HEMIAZYGOS VEIN AT ITS TERMINATION INTO THE AZYGOS VEIN

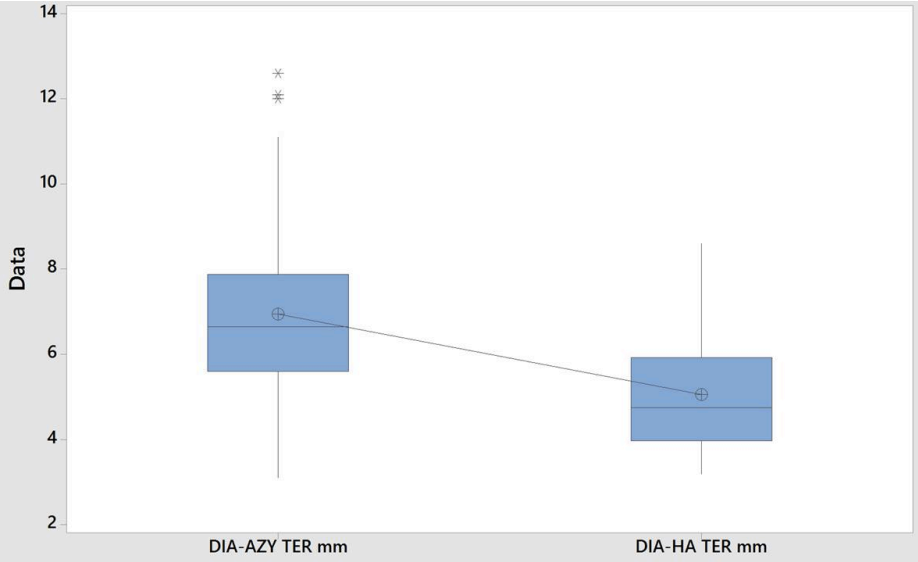


Chart 11 (a)

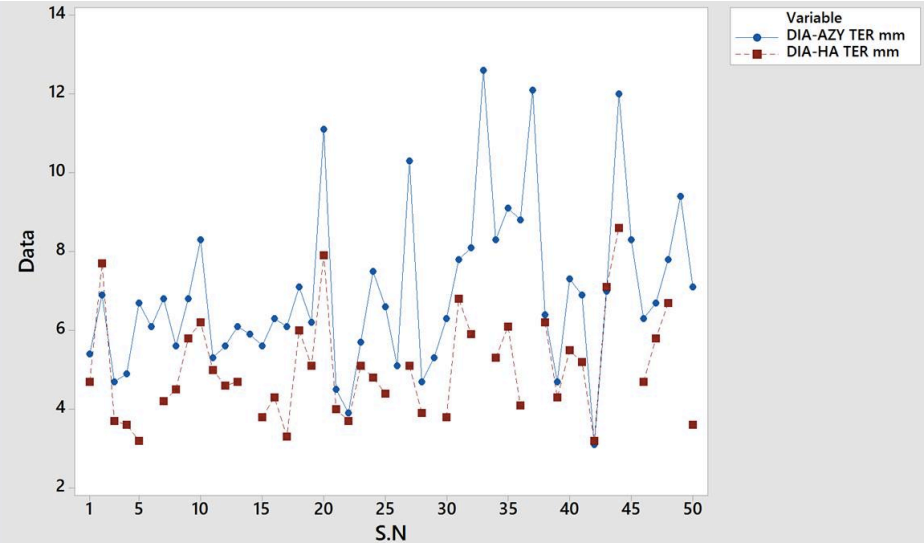


Chart 11 (b)

Chart 11 (a, b): THE COMPARISON OF DATA OF THE DIAMETER OF THE AZYGOS AND HEMIAZYGOS VEIN AT ITS TERMINATION, DIA- DIAMETER, AZY- AZYGOS VEIN, HA- HEMIAZYGOS VEIN, TER- TERMINATION.

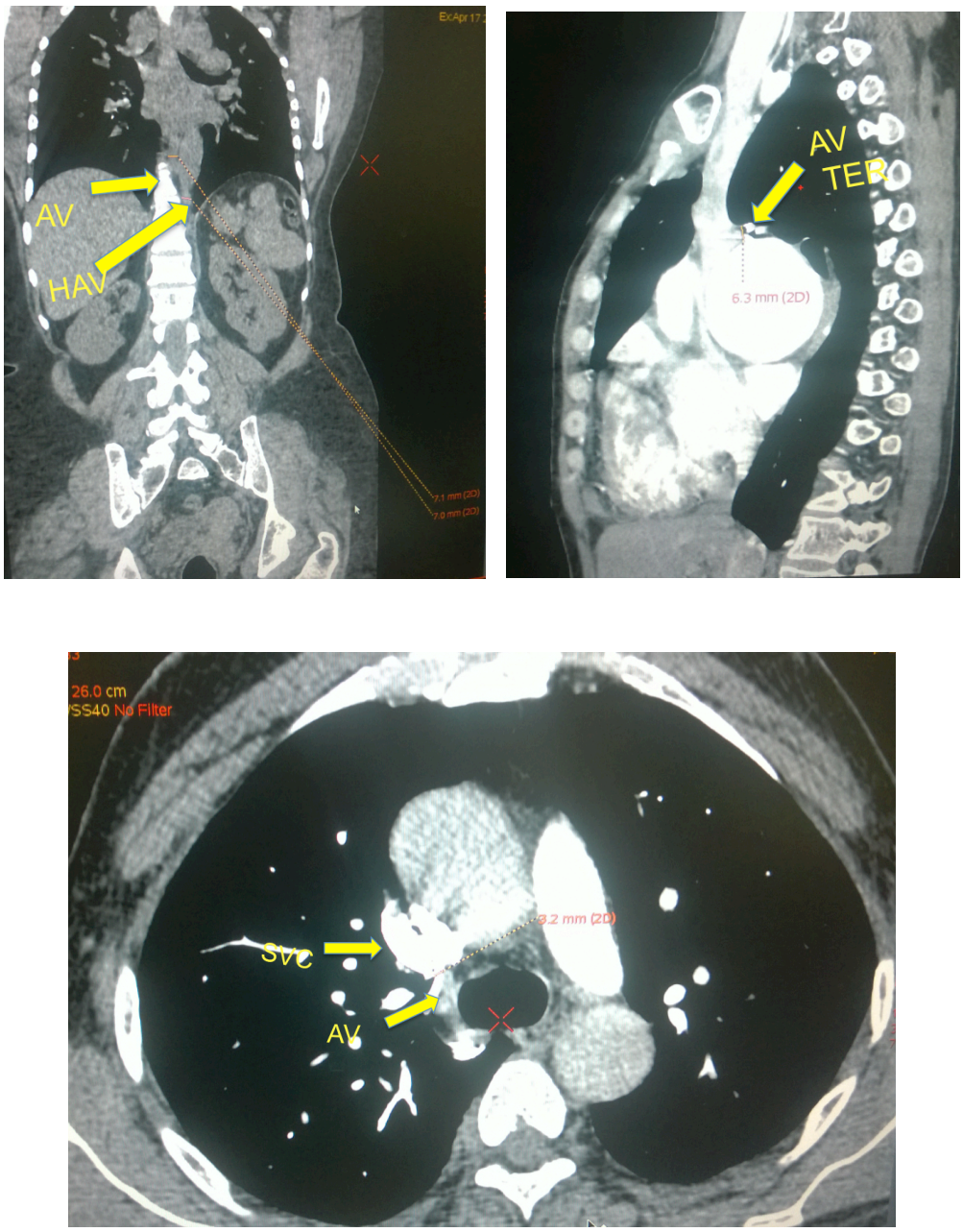


Figure 19: RADIOGRAPHIC IMAGE, SPECIMEN SHOWING THE AZYGOS AND THE HEMIAZYGOS VEIN, CT CORONAL, SAGITTAL, AXIAL VIEW,MEASUREMENT OF DIAMETER OF AZYGOS , HEMIAZYGOS VEIN AT THEIR TERMINATION, AV- AZYGOS VEIN, HAV- HEMIAZYGOS VEIN ,AV TER- AZYGOS VEIN TERMINATION

TYPE, PATTERN OF THE AZYGOS SYSTEM OF VEINS

Azygos vein is present in all the specimens (100%). The percentage of azygos vein in the specimen and the mode of formation of azygos vein have been discussed.

Among the 50 specimens analyzed, hemiazygos vein is not present in 14% (7 specimens). Out of 23 cadaver specimens in which it is present, in 96% (specimens), the hemiazygos vein is formed by a single root that is the lateral root. Out of these in 73% (16 specimens) it is formed by left ascending lumbar vein and left subcostal vein and in 23% (6 specimens) only by the left subcostal vein. In specimens numbered 3,8,16,18,25 and 27 the hemiazygos vein is formed only from the left subcostal vein. In 4% (1 specimen) it is formed by the lateral and medial roots. This is present in specimen numbered 10.

Charts 5 and 12 show the percentage of hemiazygos vein in the specimen and its mode of formation respectively.

Among the 50 specimens analyzed, the accessory hemiazygos vein is absent in 28% (14 specimens).

Chart 7 shows the percentage of accessory hemiazygos vein in the specimen.

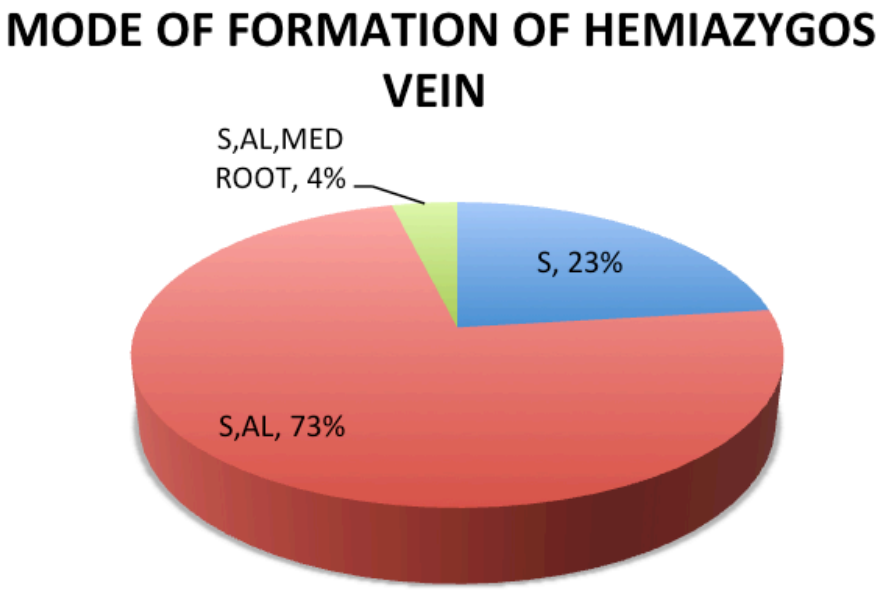


Chart 12: ***THE MODE OF FORMATION OF THE HEMIAZYGOS VEIN, S- Left Subcostal vein, AL-Left Ascending lumbar vein, MED ROOT- Medial root***

Falla, Preston & Anson BJ, classifies the pattern of azygos venous system into 3 main types and 11 groups. The same classification is followed in the present study for grouping.

Among the 30 cadaveric specimens analyzed 86.7% (26 specimens) belongs to type II, 6.7% (2 specimens) to type III and 3.3%(1 specimen) to type I and 3.3% is considered as atypical. (1specimen).

Table 5 depicts the grouping of the azygos system of veins according to Anson's classification.

GROUP	PERCENTAGE	COUNTS
1	3.3%	1
2	23.3%	7
3	3.3%	1
4	13.3%	4
5	10%	3
7	20%	6
9	6.7%	2
10	3.3%	1
11	6.7%	2
6B	6.7%	2
ATYPICAL	3.3%	1
TOTAL	100%	30

TABLE 5: GROUPING OF THE AZYGOS SYSTEM OF VEINS IN CADAVERIC SPECIMENS ACCORDING TO ANSONS CLASSIFICATION

Type I Group 1:

It consists of two completely separate and parallel veins. They are the azygos vein on the right and continuous single vein on the left. This pattern is present in 3.3% (1 specimen) among the 30 cadaveric specimens.

This is present in cadaveric specimen numbered 29. This is also seen in one radiologic specimen.

Type II Group 2:

There is one midline horizontal communication between right and left trunk, usually at level of eighth thoracic vertebra. This is noted in 23.3%(7 cadaveric specimens) among the total of 30.

The specimens numbered 3, 4, 11, 13, 16, 17 and 21 belong to this pattern.

Type II Group 3:

There is one horizontal communication between right and left trunk at a higher vertebral level. Among 30 cadaveric specimens it is present in 3.3% (1 specimen).

In the specimen numbered 7 this pattern is present.

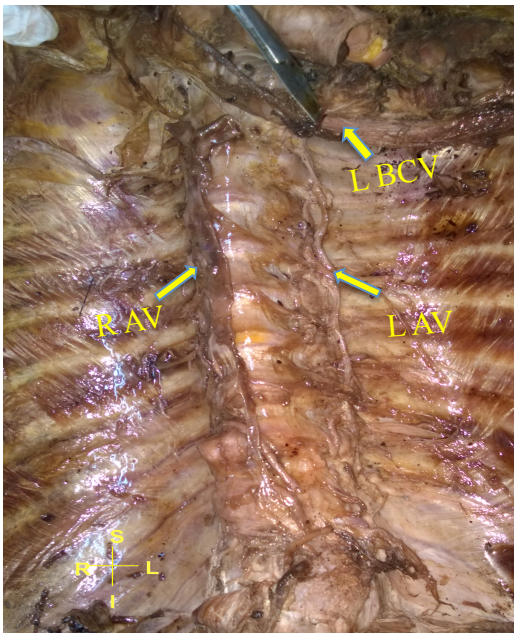


Figure 20: SPECIMEN SHOWING TYPE I AZYGOS VENOUS SYSTEM SHOWING THE AZYGOS VEIN ON THE RIGHT SIDE AND SINGLE LEFT AZYGOS VEIN WITH NO INTERVERTEBRAL CONNECTION WITH THE RIGHT AZYGOS VEIN, THE LEFT AZYGOS VEIN DRAINING INTO THE LEFT BRACHIOCEPHALIC VEIN, *RAV-RIGHT AZYGOS VEIN, LAV- LEFT SINGLE AZYGOS VEIN,LBCV-LEFT BRACHIOCEPHALIC VEIN.*

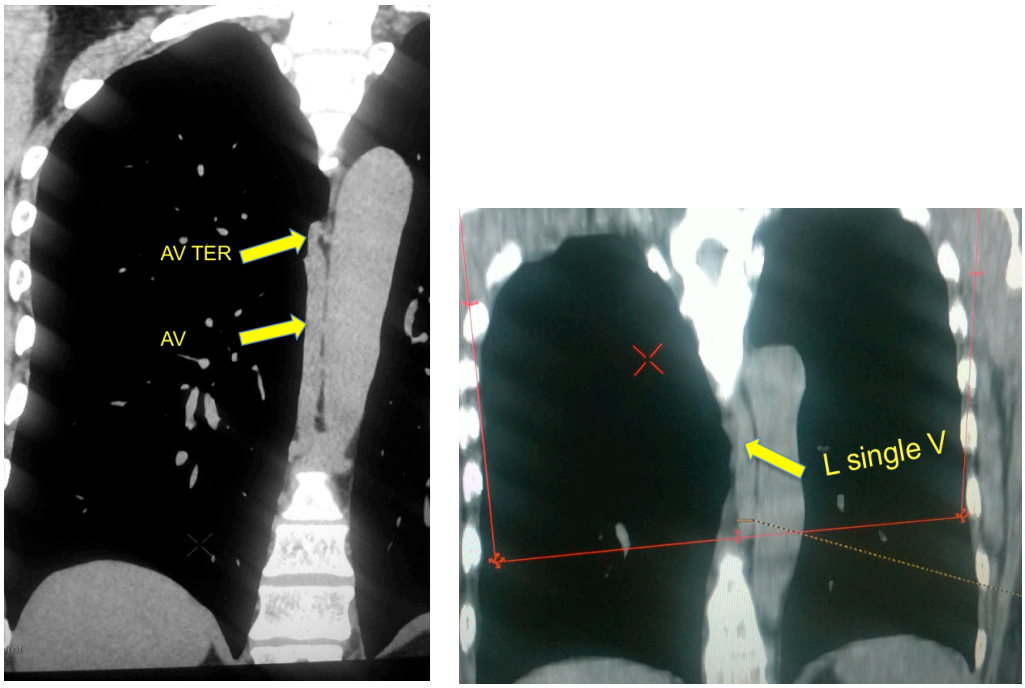


Figure 21: RADIOGRAPHIC IMAGE, SPECIMEN SHOWING AZYGOS AND HEMIAZYGOS VEINS, CT CORONAL VIEW, *AV- AZYGOS VEIN, L single V—LEFT SINGLE VEIN ACCESSORY (SUPERIOR) AND INFERIOR HEMIAZYGOS JOINED AS A SINGLE VEIN, AV TER- AZYGOS VEIN TERMINATION INTO SUPERIOR VENACAVA.* ***NO COMMUNICATION PRESENT BETWEEN THE TWO VEINS, CLASSIFIED AS TYPE I GROUP 1***

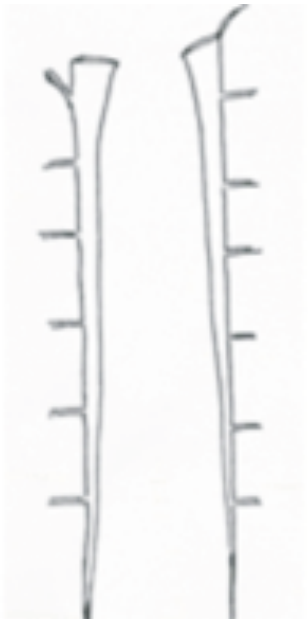


Figure 22: SPECIMEN 29 BELONGING TO TYPE I GROUP 1 AND SCHEMATIC REPRESENTATION. It consists of two completely separate, parallel veins, the azygos on the right, and continuous single vein on the left.

Figure 23: SPECIMEN 3 BELONGING TO TYPE II GROUP 2 AND SCHEMATIC REPRESENTATION. There is one midline horizontal connection between right and left trunk, usually at level of T8 .

Figure 24: SPECIMEN 4,11,13 BELONGING TO TYPE II GROUP 2 AND SCHEMATIC REPRESENTATION. There is one midline horizontal connection between right and left trunk, usually at level of T8 .

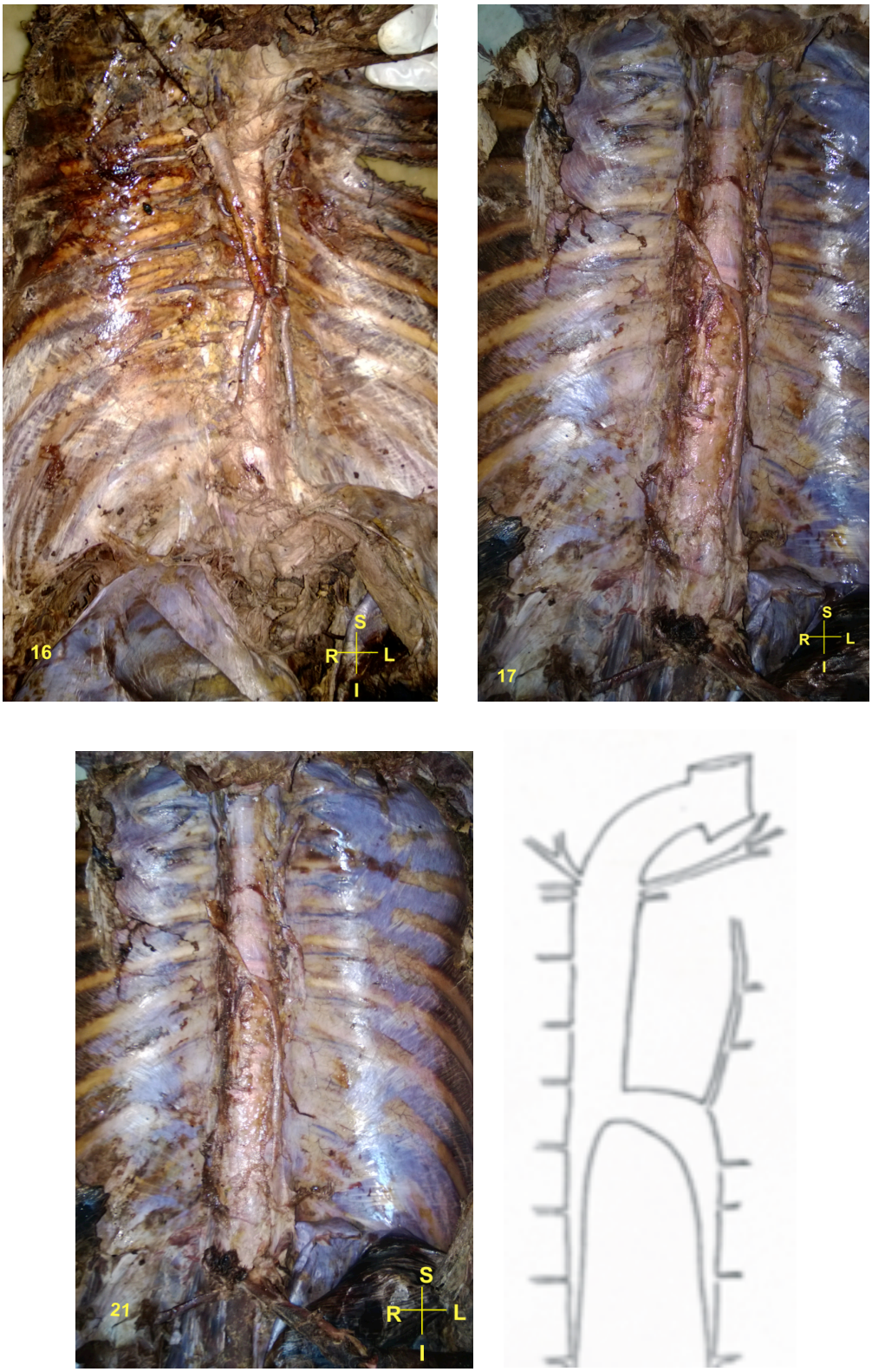


Figure 25: SPECIMEN 16,17,21 BELONGING TO TYPE II GROUP 2 AND SCHEMATIC REPRESENTATION. There is one midline horizontal connection between right and left trunk, usually at level of T8 .

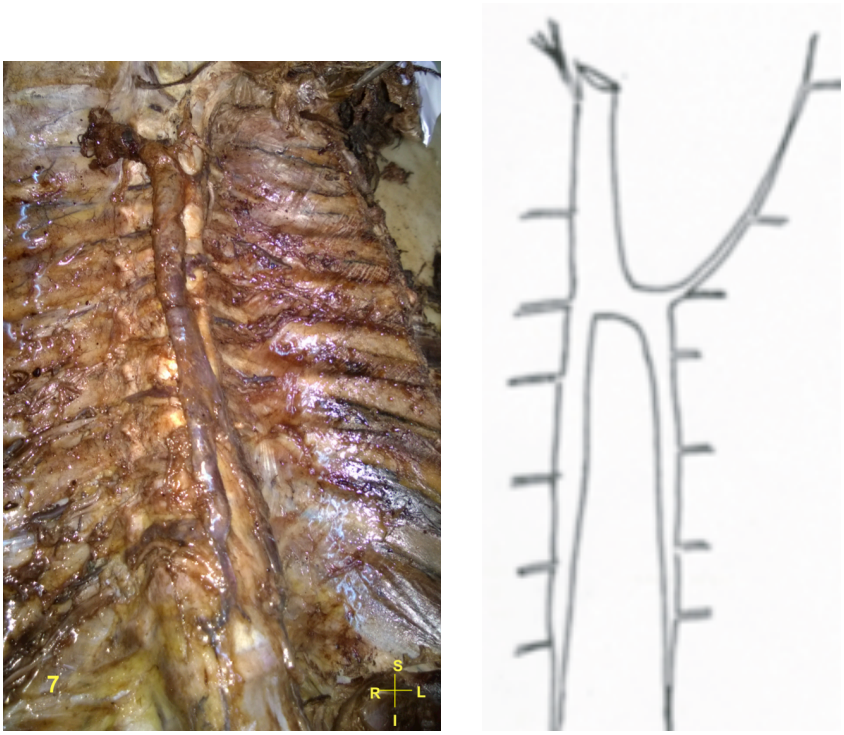


Figure 26: SPECIMEN 7 BELONGING TO TYPE II GROUP 3 AND SCHEMATIC REPRESENTATION. There is one horizontal connection between right and left trunk at a higher vertebral level

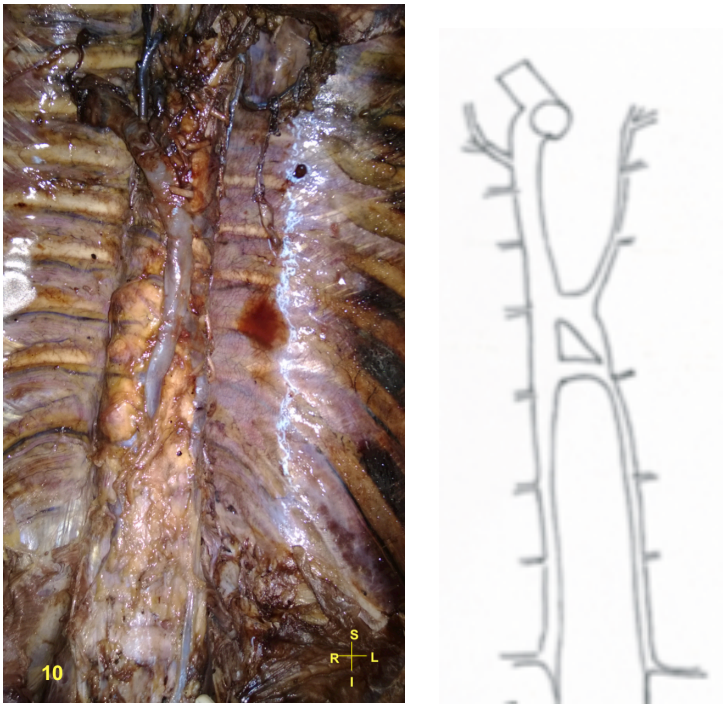


Figure 27: SPECIMEN 10 BELONGING TO TYPE II GROUP 4 AND SCHEMATIC REPRESENTATION. There are two horizontal connections between right and left trunk.

Type II Group 4:

There are two horizontal communications between right and left trunk. Out of 30 cadaveric specimens, it is present in 13.3% (4 specimens).

This pattern is present in specimens numbered 10,20,22 and 27.

Type II Group 5:

There are three to five horizontal communications between right and left trunk, which are seen in 10%(3 specimens) among the 30 cadaveric specimens.

The specimens numbered 1,8 and 25 belong to this pattern.

Type II Group 6:

The trunk on the left side is broken once. This group is again divided into i) Group 6A, where there is connection between the accessory hemiazygos vein and the left brachiocephalic trunk vein, and

ii) Group 6B, where there is no connection between the accessory hemiazygos vein and the left brachiocephalic trunk vein.

In the present study, no group 6A pattern is seen. Group 6B pattern is seen in 6.7% (2 specimens). This pattern is present in specimens numbered 5 and 24.

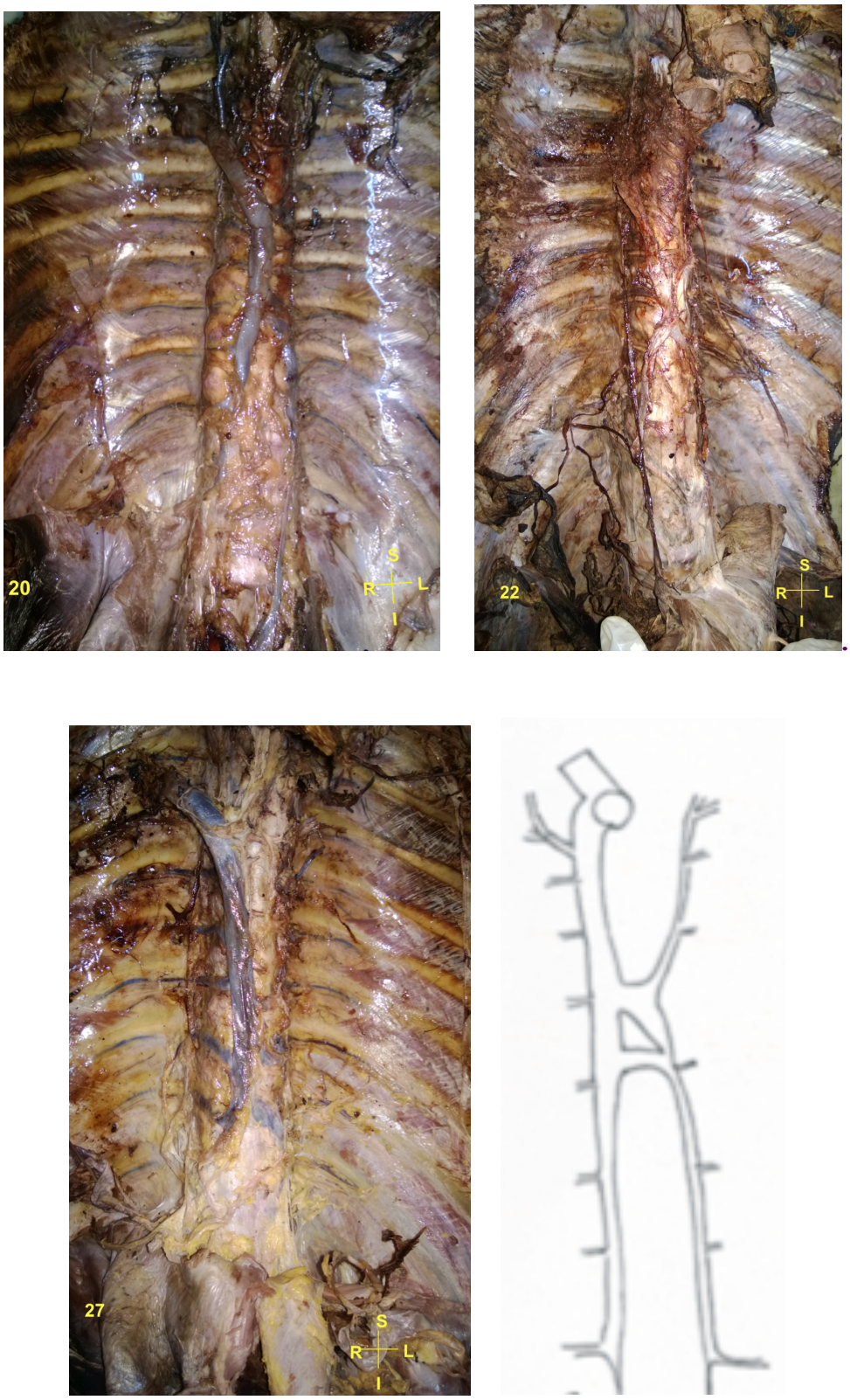


Figure 28: SPECIMEN20,22, 27 BELONGING TO TYPE II GROUP 4 AND SCHEMATIC REPRESENTATION . There are two horizontal connections between right and left trunk.

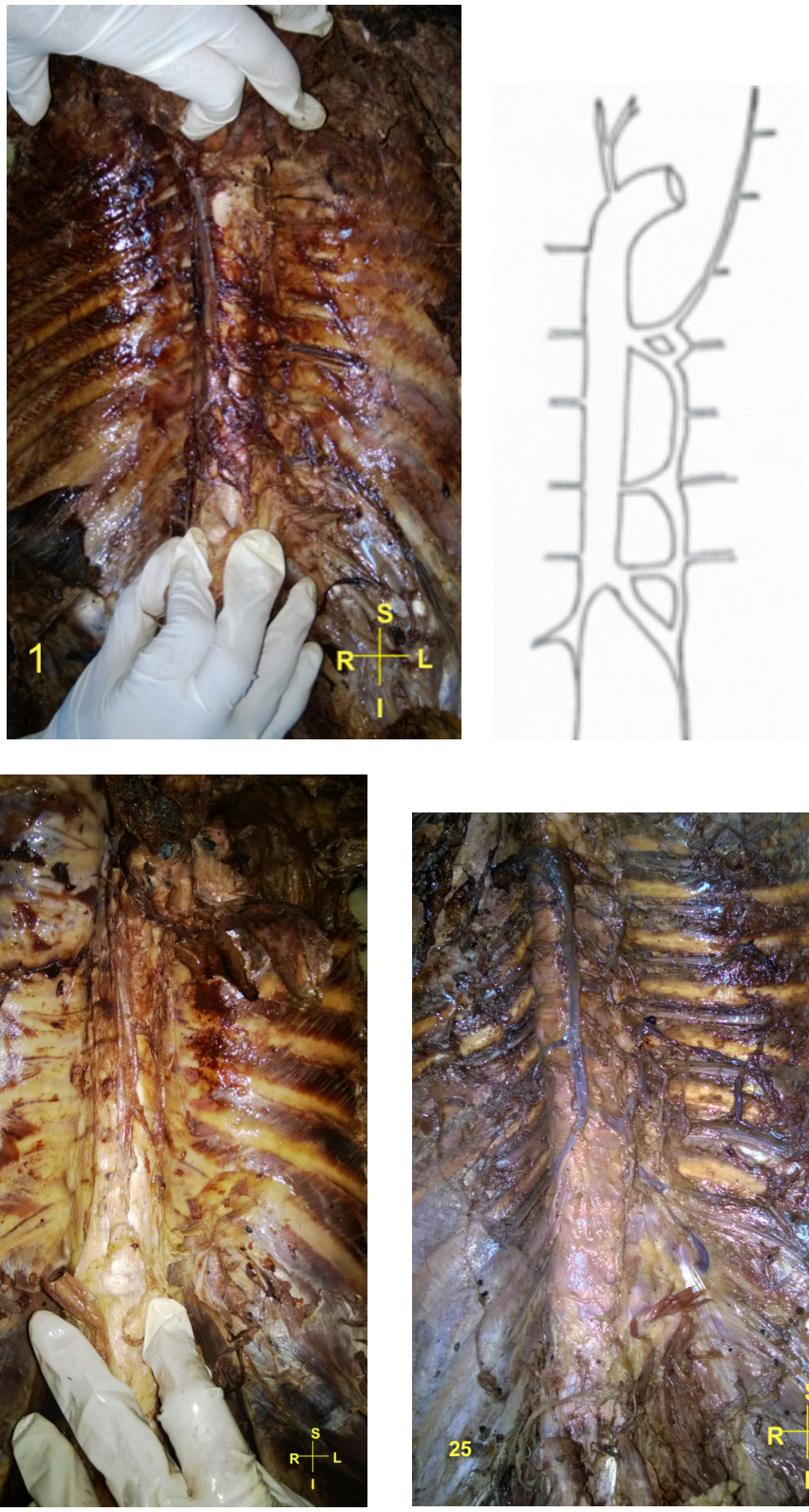


Figure 29: SPECIMEN 1,8,25 BELONGING TO TYPE II GROUP 5 AND SCHEMATIC REPRESENTATION. There are three to five horizontal connections between right and left trunk .

Figure 30: SPECIMEN 5,24 BELONGING TO TYPE II GROUP 6B AND SCHEMATIC REPRESENTATION. The trunk of the left side is broken once and there is no connection between accessory hemiazygos vein and left brachiocephalic trunk vein

Type II Group 7:

There are two breaks in left trunk. Among 30 cadaveric specimen 20% (6 specimens) belong to this type.

This pattern is present in specimens numbered 2,9,15,19,28 and 30.

Type II Group 8:

There is one break in the left trunk. Collaterals, above and below it, join posterior intercostal veins.

This pattern is not seen in this study.

Type II Group 9:

There are 5 breaks in the lower part of the left trunk. Joining of 11th, 12th and 10th, 9th posterior intercostal veins form two single veins, in the lower part. In this study 6.7% (2 cadaveric specimens) belong to this type.

The specimens numbered 12 and 23 belong to this pattern.

Type II Group 10:

There are 5 breaks in the lower part of the left trunk. 3.3% (1 cadaveric specimen) with this pattern of azygos system is seen.

In the specimen numbered 18 this pattern is present.

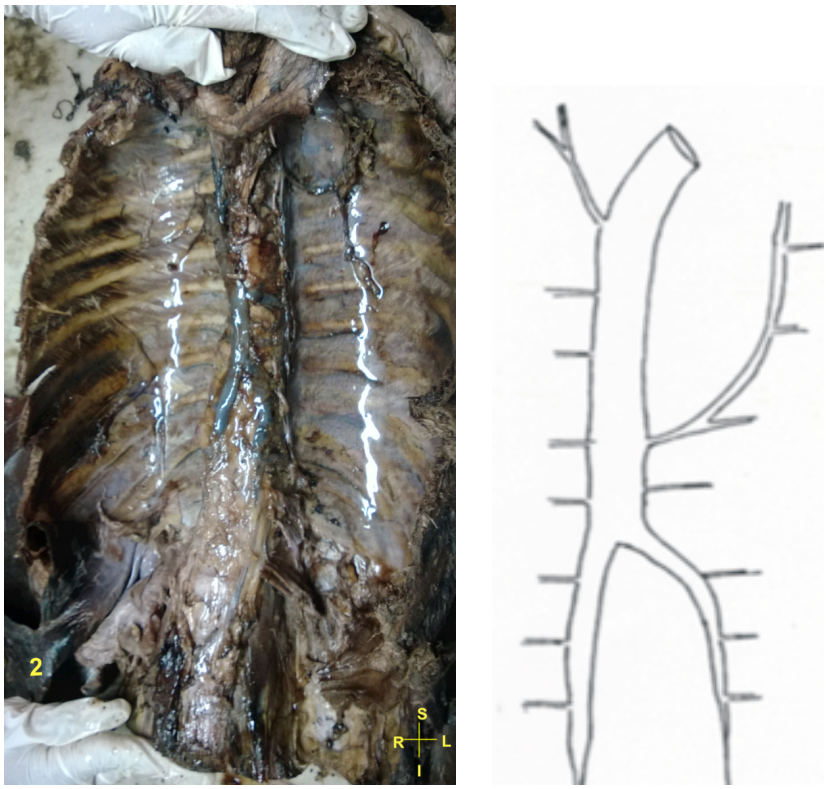


Figure 31: SPECIMEN 2,9,15 BELONGING TO TYPE II GROUP 7 AND SCHEMATIC REPRESENTATION. The trunk of the left side is broken twice.

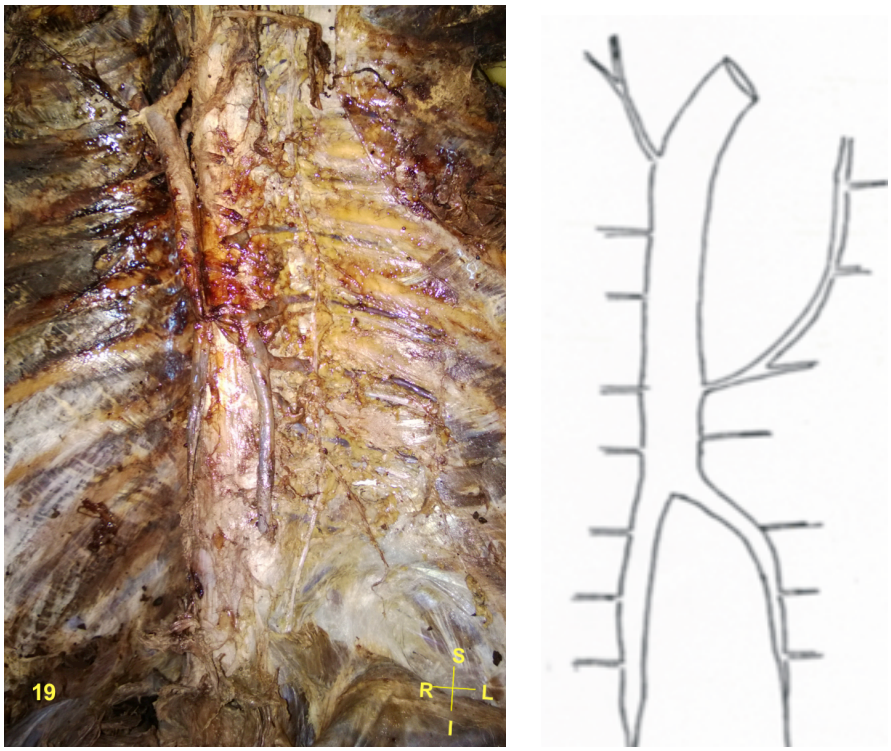


Figure 32: SPECIMEN 19,28,30 BELONGING TO TYPE II GROUP 7 AND SCHEMATIC REPRESENTATION. The trunk of the left side is broken twice

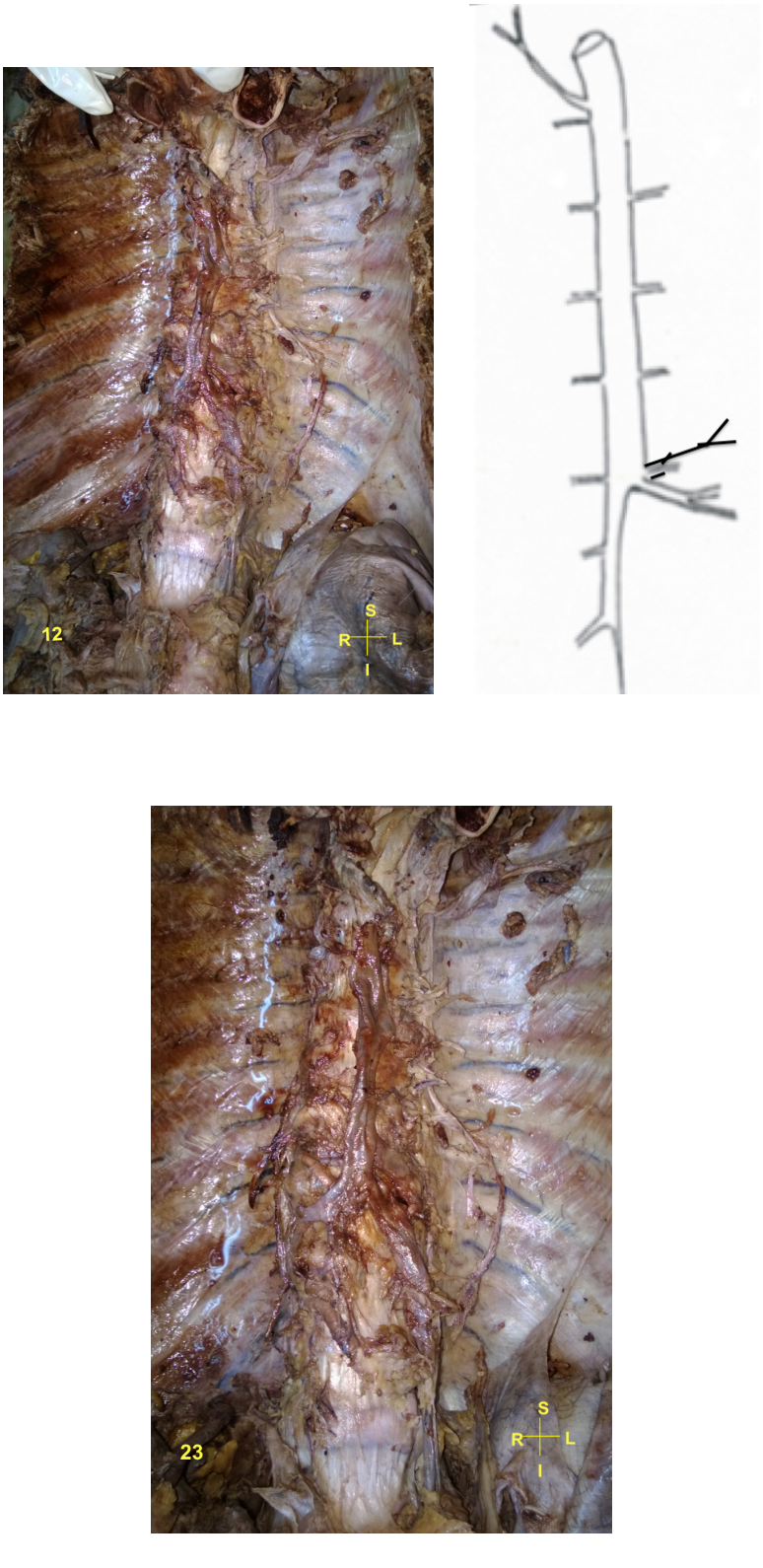


Figure 33: SPECIMEN 12,23 BELONGING TO TYPE II GROUP 9 AND SCHEMATIC REPRESENTATION. There are 5 breaks in the lower part of the left trunk and two single veins, in the lower part.

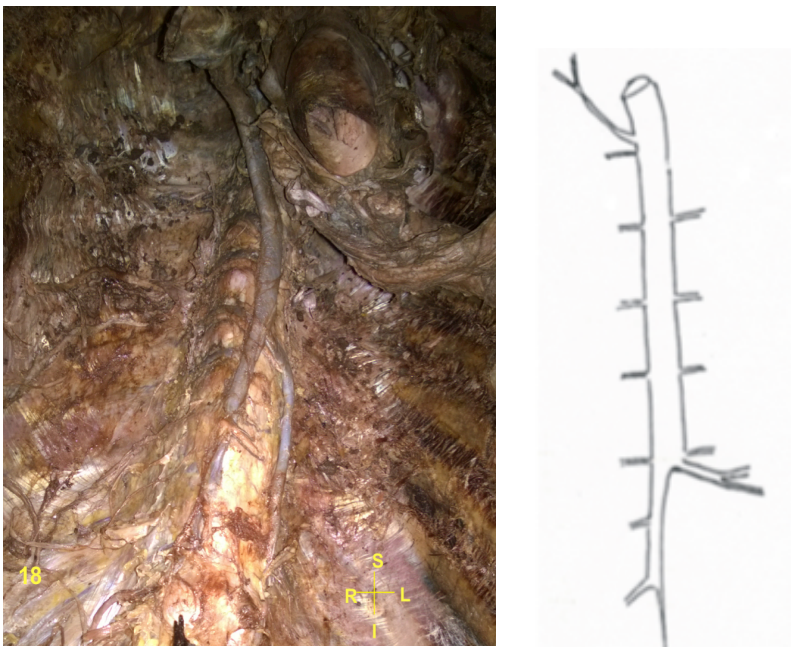


Figure 34: SPECIMEN 18 BELONGING TO TYPE II GROUP 10 AND SCHEMATIC REPRESENTATION. There are 5 breaks in the lower part of the left trunk.

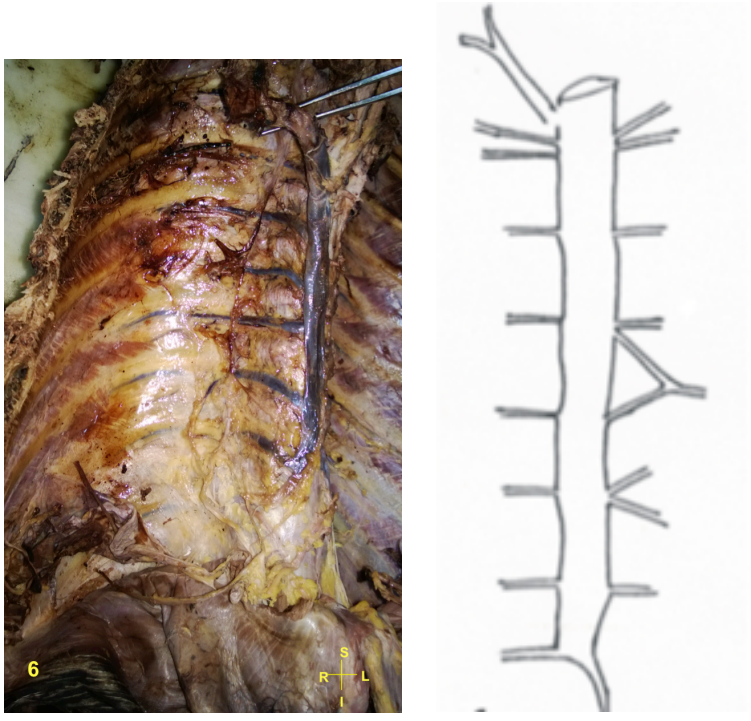


Figure 35: SPECIMEN 6 BELONGING TO TYPE III GROUP 11 AND SCHEMATIC REPRESENTATION*. There is a single azygos vein occupying the midline of the vertebral column.*

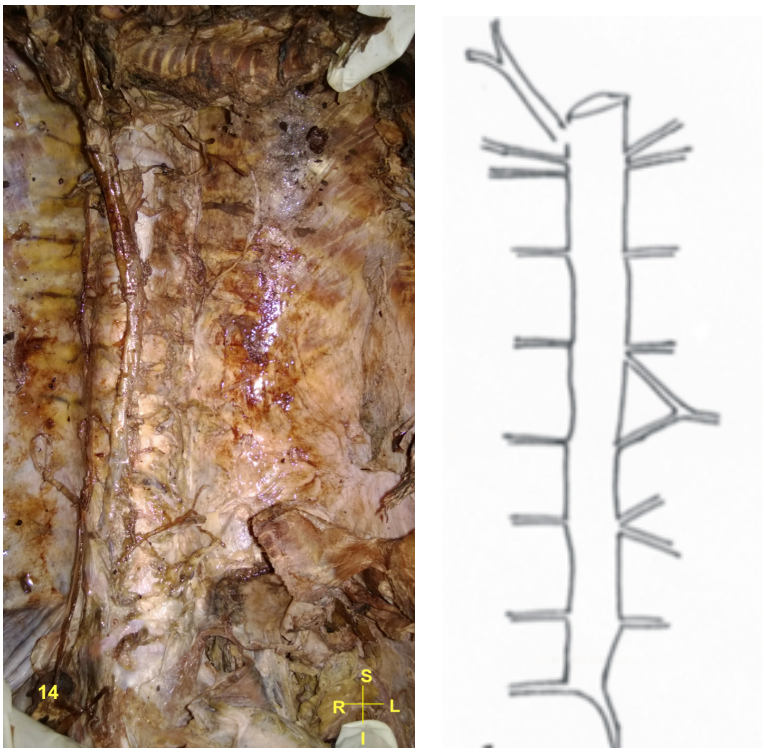


Figure 36: SPECIMEN 14 BELONGING TO TYPE III GROUP 11 AND SCHEMATIC REPRESENTATION*. There is a single azygos vein occupying the midline of the vertebral column.*

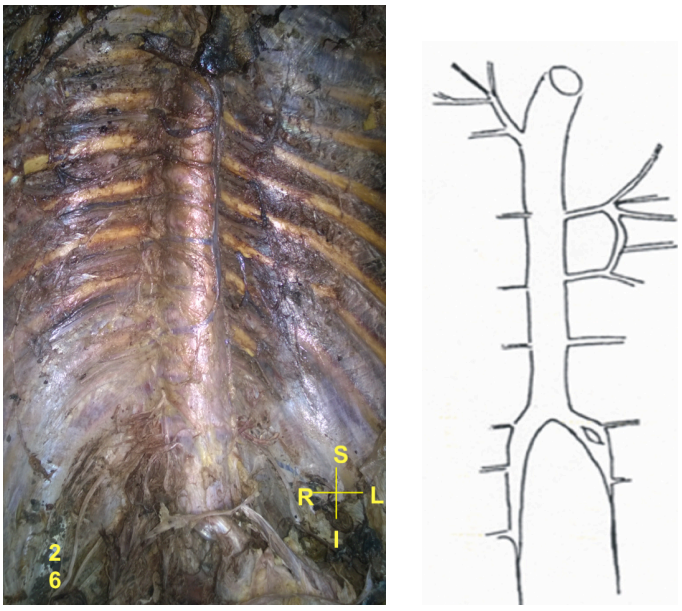


Figure 37: SPECIMEN 26 CLASSIFIED ATYPIC AND SCHEMATIC REPRESENTATION*. It was not fulfilling the criteria under Ansons system of classification.*

Type III Group 11:

It consists of a single azygos vein occupying the midline of the vertebral column.

In the present study among the 30 cadaveric specimens this pattern of azygos venous system is present in 6.7%(2 cadaveric specimens).

The specimens numbered 6 and 14 belong to this pattern. This pattern is also seen in three radiologic specimens.

In 3.3% (1 specimen) classified as atypical the pattern of azygos venous system is not fulfilling the above criteria. In the present study the specimen numbered 26 is classified as atypical.

Chart 13 shows the type and Chart 14 depicts the grouping of azygos system of veins according to Anson's classification.

In the present study there are no associated anomalies of superior and inferior vena cava.

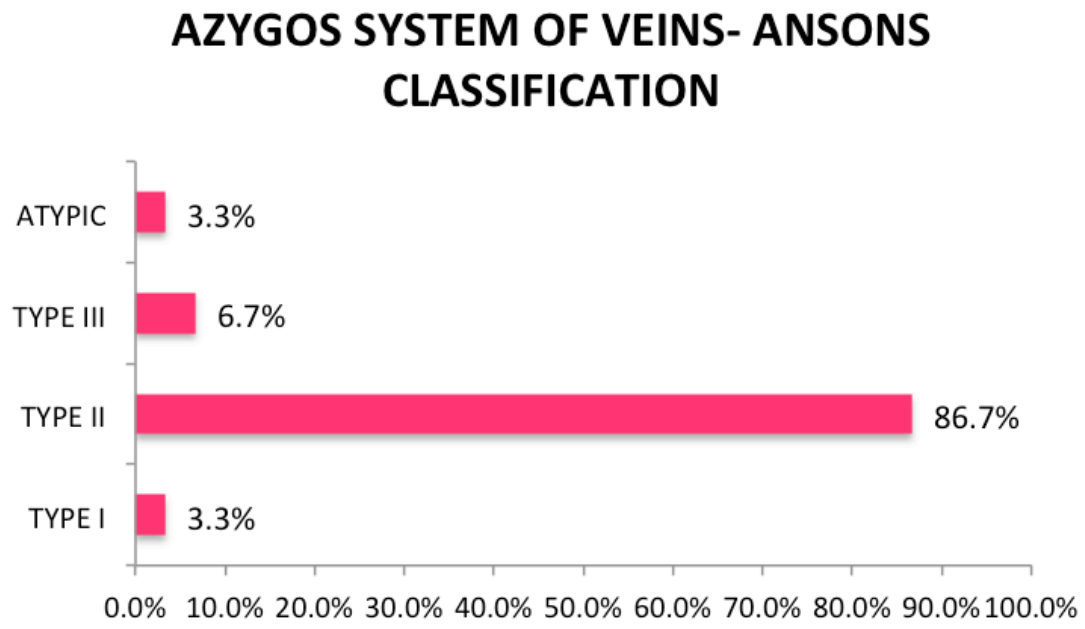


Chart 13: TYPE OF THE AZYGOS SYSTEM OF VEINS ACCORDING TO ANSONS CLASSIFICATION

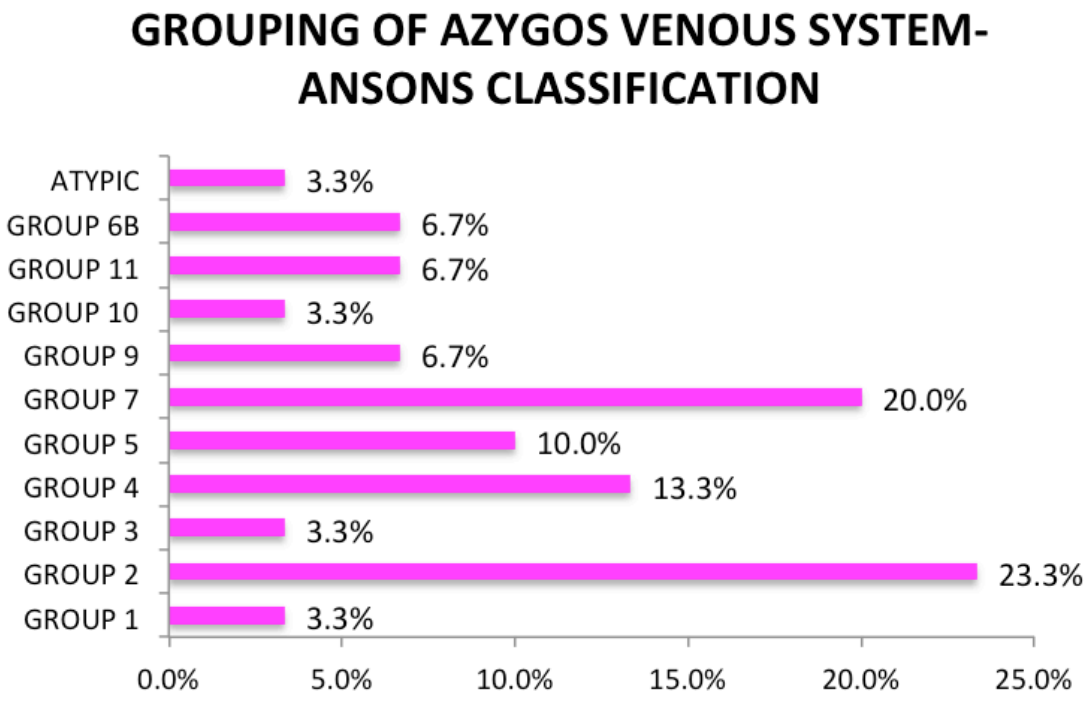


Chart 14: GROUPING OF THE AZYGOS VENOUS SYSTEM ACCORDING TO ANSONS CLASSIFICATION

DISCUSSION

MODE OF FORMATION OF AZYGOS VEIN

Azygos vein is formed mostly by the right ascending lumbar vein and the right subcostal vein according to Lockert et al, Latajet &Ruiz Liard, Hollinshead, Gardner et al, Spalteholz and E.R.Heitzman [33,34,94,44,65]. In the present study azygos vein is formed in 67% by the ascending lumbar and the subcostal veins.

In Elton Correia Alves et al (2011) [2] study the common structure noted in the formation of the azygos vein is the right subcostal vein (93.3%). In the present study also the common structure is the right subcostal vein, which is present in all 30 cadaveric specimens (100%)

According to Williams et al, Kanchana Latha et al (2013) [69] studies azygos vein is formed only from right subcostal vein in 12%. In Elton Correia Alves et al (2011) [2] study the azygos vein is formed only from the subcostal vein in 43.3%. In the present study the azygos vein is formed only from subcostal vein in 23%.

Chart 15 shows the comparison of the mode of formation of azygos vein only from the subcostal vein, in the present study with the above-mentioned studies.

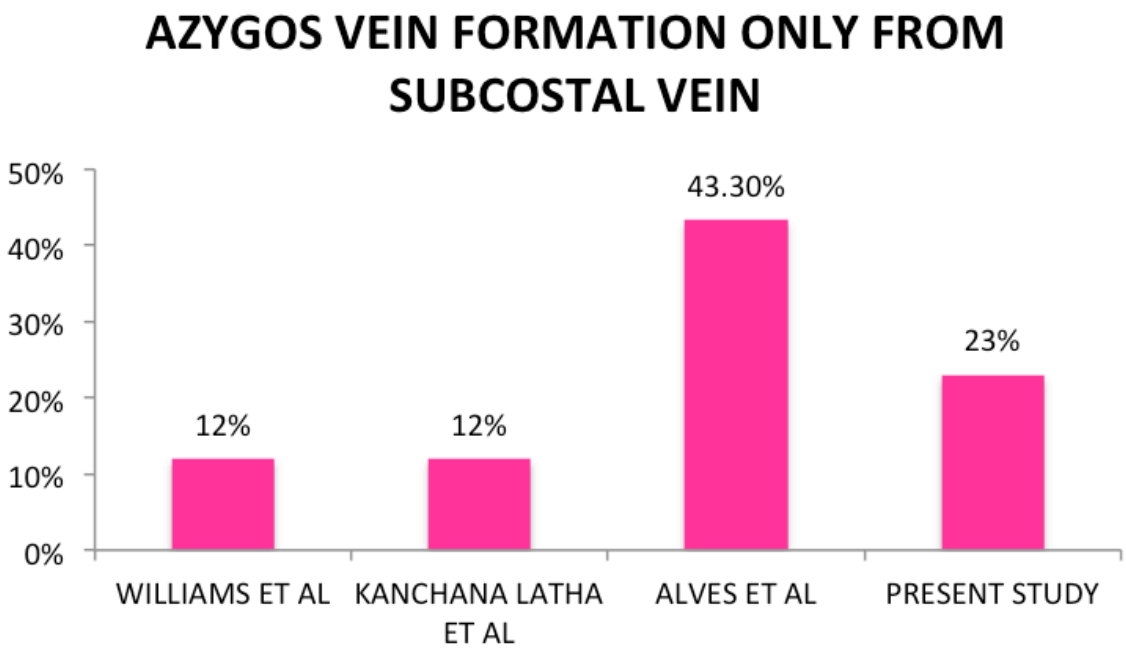


Chart 15: COMPARISON OF PRESENT STUDY WITH OTHER STUDIES, THE AZYGOS VEIN FORMATION ONLY FROM THE SUBCOSTAL VEIN

According to George AS et al [63], the incidence of lateral root in the formation of azygos vein is 94% intermediate root is 45% and medial root is 39%.

Bergman RB et al [10] states that in the formation of azygos vein the incidence of lateral root is 84%; intermediate root 34% and medial root 38%.

According to Woodbourne [81], the incidence of the lateral root is 94%, intermediate root 45% and medial root is 30% in the formation of azygos vein.

In Kanchana Latha et al (2013) [69] study the formation of the azygos vein is only by the lateral root (100%).

In the present study the presence of lateral root is 100%, which is present in all 30 cadaveric specimens. Intermediate root is present in 10% (3 cadaveric specimens) and medial root in 3% (1 cadaveric specimen). This is comparable with Kanchana Latha et al studies in which also the presence of lateral root is 100% and also with other studies mentioned above in which the presence of lateral root is the highest.

Chart 16 shows the comparison of the mode of formation of azygos vein in the present study with the above-mentioned studies.

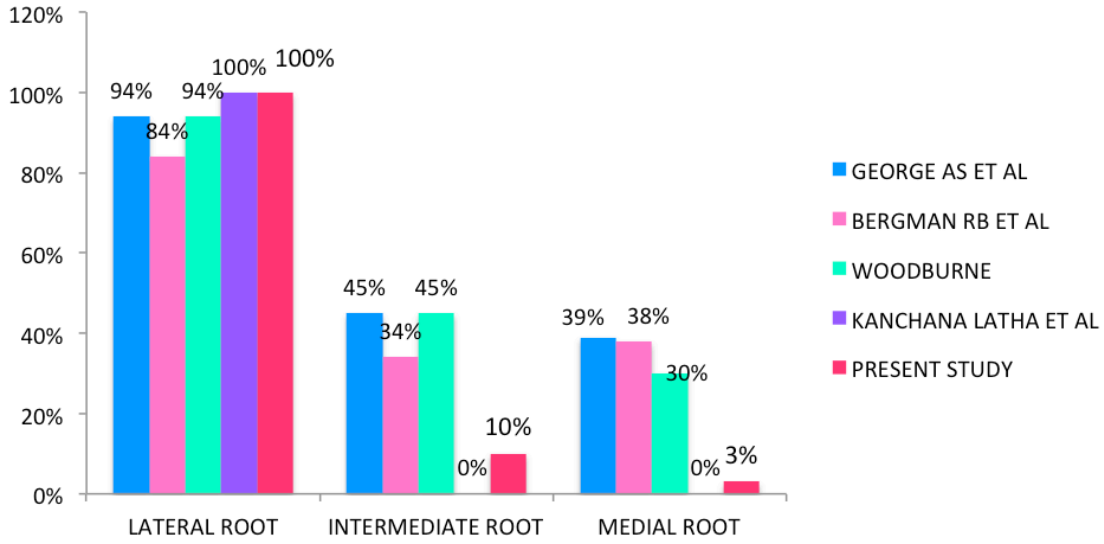


***Chart 16:** COMPARISON OF PRESENT STUDY WITH OTHER STUDIES, MODE OF FORMATION OF THE AZYGOS VEIN FROM LATERAL , INTERMEDIATE AND MEDIAL ROOTS*

In Elton Correia Alves et al (2011) [2] study the azygos vein is formed by single root in 50%. Two roots form it in 30% and three roots in 20%.

In Kanchana Latha et al (2013) [69] study the formation of the azygos vein is only by single root (100%). In the present study single root in 90%, two roots in 7% and three roots in 3% formed azygos vein. In all the three studies the mode of formation is mainly by single root.

Chart 17 shows the comparison of the mode of formation of the azygos vein by single, two and three roots in the present study with the above-mentioned studies.

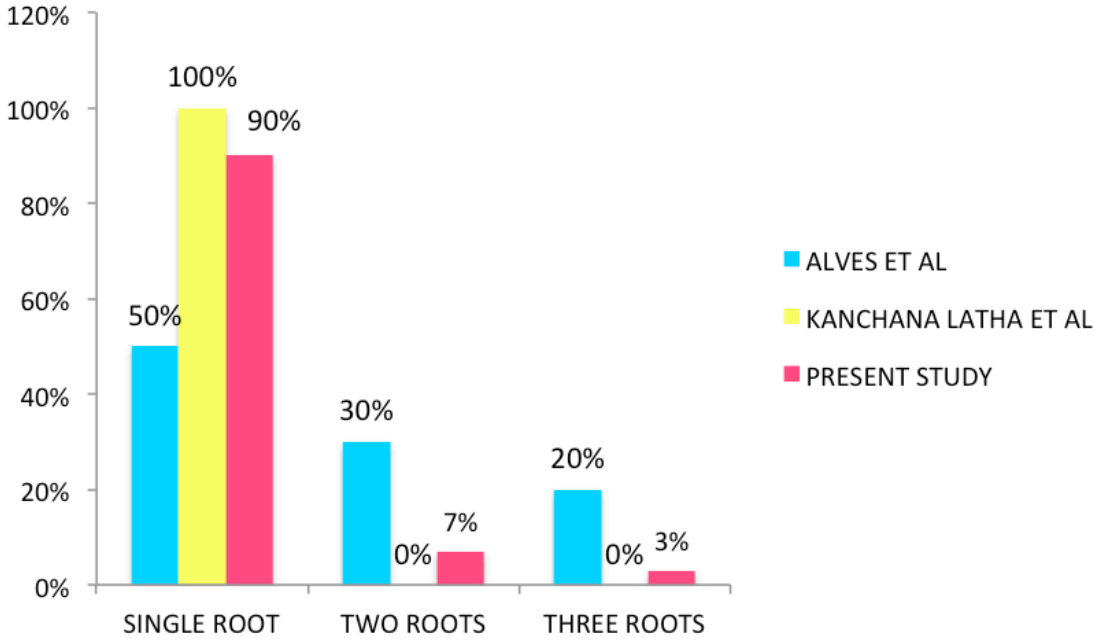


Chart 17: COMPARISON OF PRESENT STUDY WITH OTHER STUDIES, MODE OF FORMATION OF THE AZYGOS VEIN BY SINGLE ROOT, TWO ROOTS, THREE ROOTS

COURSE OF THE AZYGOS VEIN IN RELATION TO MIDLINE OF THE VERTEBRAL COLUMN

According to Hollingshead [34] the azygos vein normally passes upward on the right side of the vertebral column before it ends in the superior vena cava.

According to Elzbieta Krakowiak Sarnowska et al [22] studies the azygos vein is present 90.6% on right side to the midline and 9.4 % on midline of the vertebral column.

Tatar et al (2008) [36] study states that the azygos vein is on the right side of midline in 37.9%, left side of midline in 22.3% and at the midline of vertebral column in 39.8%.

In Nathan H study [53], in 20% the azygos vein is on the right, 27% at the midline and 53% in the left.
In Kagami study [39], in 4% the azygos vein is on the right, 11% at the midline and 85% crosses to the left.

In the present study azygos vein is present to the right of midline of the vertebral column in 62%, the left in 22 % and in the midline in 16%. This study finding correlates with Hollingshead [34] which states that the position of azygos vein is normally on the right side of the midline of the vertebral

column. This study also correlates with Elzbieta study where the majority of position of the azygos vein is on right side.

It differs from Tatar et al study in which the azygos vein is present in equal proportions in the right side and at midline while in the present study it is mostly present on the right side of the vertebral column. It also differs from Nathan H and Kagami study where the azygos vein is present mostly on the left side while in the present study it is mostly on the right side.

Chart 18 compares the course of the azygos vein in relation to midline of the vertebral column in the present study with the above studies.

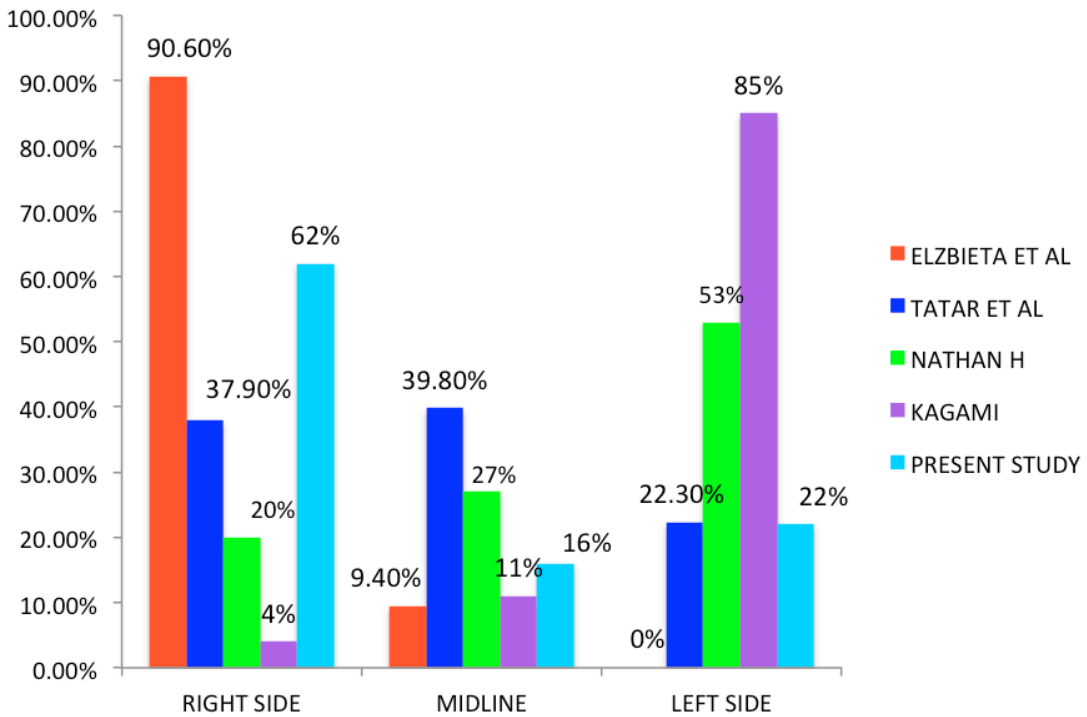


Chart 18: COMPARISON OF PRESENT STUDY WITH OTHER STUDIES, COURSE OF THE AZYGOS VEIN TO THE RIGHT SIDE, MIDLINE AND LEFT OF THE VERTEBRAL COLUMN

LEVEL OF ARCHING OF THE AZYGOS VEIN AND LEVEL OF TERMINATION INTO THE SUPERIOR VENACAVA

In the study by George AS [11] 33.6% of azygos arch are at fifth thoracic vertebral level and 32.6% are at intervertebral disc of fourth and fifth thoracic vertebra. According to Tatar et al (2008) [36] the arching of azygos vein is at fourth thoracic vertebral level in 40%, at fifth thoracic vertebral level in 55%, and at sixth thoracic vertebral level in 5%.

In the present study the level of arching of azygos vein is at fourth thoracic vertebral level in 48%, fifth thoracic vertebral level in 38% and sixth thoracic vertebral level in 14%.

Figure 19 compares the level of arching of the azygos vein in the present study with the findings of Tatar et al study.

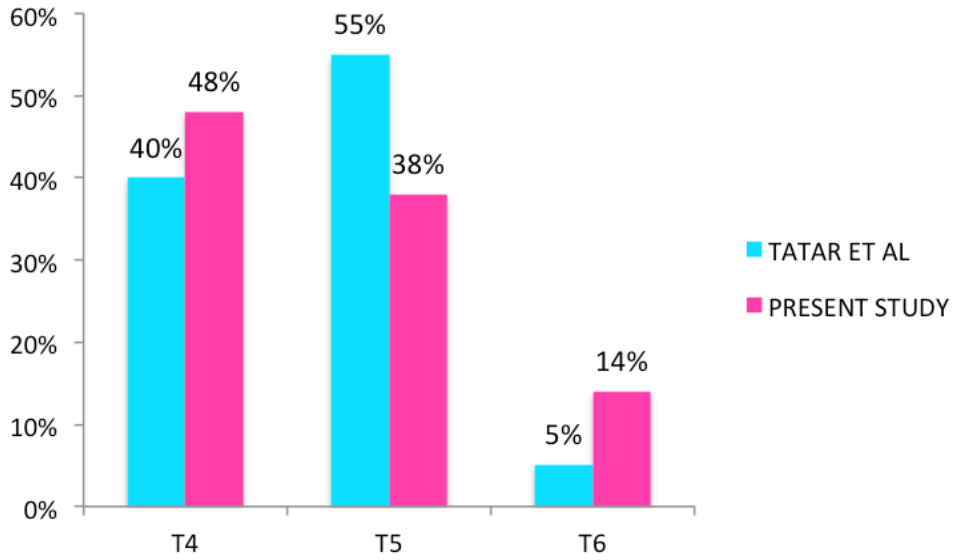


Chart 19: COMPARISON OF PRESENT STUDY WITH TATAR ET AL STUDY, LEVEL OF ARCHING OF THE AZYGOS VEIN, T4-6 VERTEBRAL LEVELS

According to Kanchana latha et al (2013) [69] study the termination of azygos vein is seen at the fourth thoracic vertebral level in 85%, third thoracic vertebral level in 8% and fifth thoracic vertebral level in 7%. According to Kutoglu (2012) study [71], the termination level of the azygos vein is at third thoracic vertebral level in 85%, at intervertebral disc between second and third thoracic vertebral level in 12%, at second thoracic vertebra and intervertebral disc between third and fourth vertebral levels in 2% each.

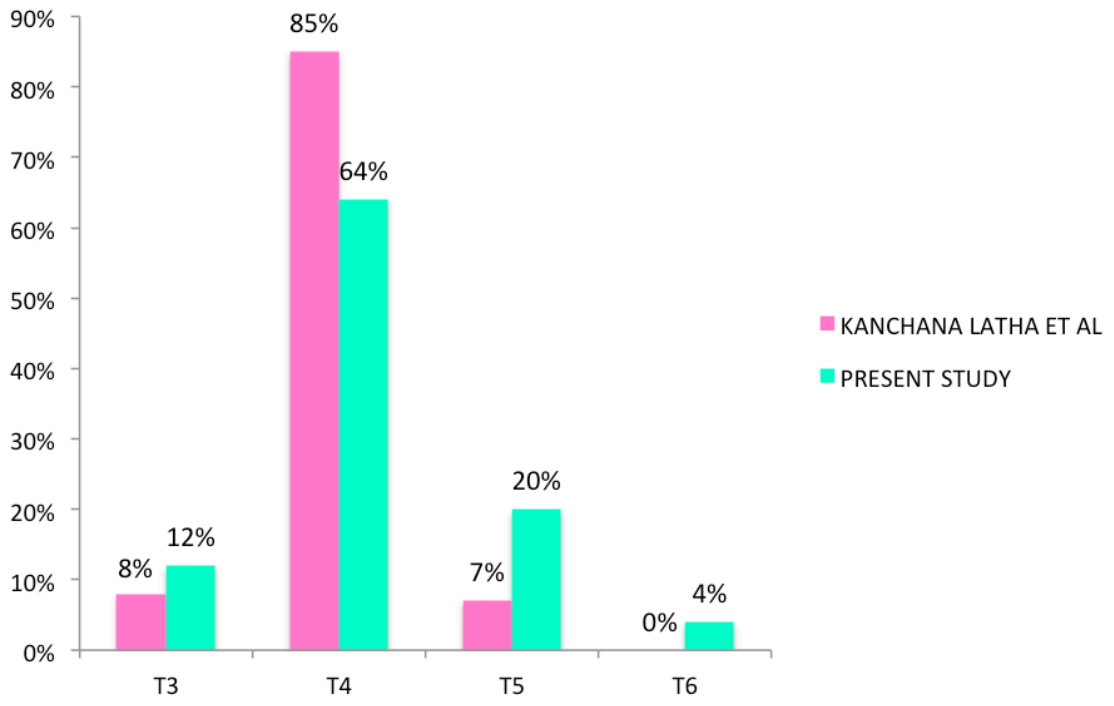


Chart 20 : COMPARISON OF PRESENT STUDY WITH KANCHANA LATHA ET AL STUDY, LEVEL OF TERMINATION OF AZYGOS VEIN INTO SUPERIOR VENCAVA, T3-6 VERTEBRAL LEVEL

In this study the level of termination of azygos vein into the superior venacava is at fourth thoracic vertebral level in 64%, fifth thoracic vertebral level in 20%, third thoracic vertebral level in 12% and at sixth thoracic vertebral level in 4%.

Comparing Kanchana latha et al and the present study in majority of the specimens the termination level is at fourth thoracic vertebral level which is in contrast to Kutoglu (2012) study where the termination level is at the level of third thoracic vertebra.

Chart 20 compares the level of termination of azygos vein into the superior venacava in the present study with Kanchana Latha et al study.

The incidence of azygos lobe of the right lung in routine Anatomic dissections is 1% and in Chest radiograms is 0.4%. In the present study azygos lobe is present in one radiologic specimen (2%).

LEVEL OF TERMINATION OF THE HEMIAZYGOS AND THE ACCESSORY HEMIAZYGOS VEIN

According to Kanchana latha et al study [69] hemiazygos termination is at the eighth vertebral level in 70 % and at ninth vertebral level in 3 %.

In Kutoglu et al study [71], 27.1 % and 20.8% of specimens the termination of hemiazygos vein is at eighth and ninth thoracic vertebral levels respectively.

In this study termination of hemiazygos vein was at eighth thoracic vertebral level in 40 %, ninth thoracic vertebral level in 40 %.

Kutoglu et al states the termination of accessory hemiazygos vein at vertebral levels between sixth and ninth thoracic vertebra. In the present study also the termination of accessory hemiazygos vein is between sixth and ninth thoracic vertebral levels.

Chart 21 depicts the comparison of the level of termination of the hemiazygos vein into the azygos vein in the present study, with the findings of Kanchana latha et al and Kutoglu et al studies.

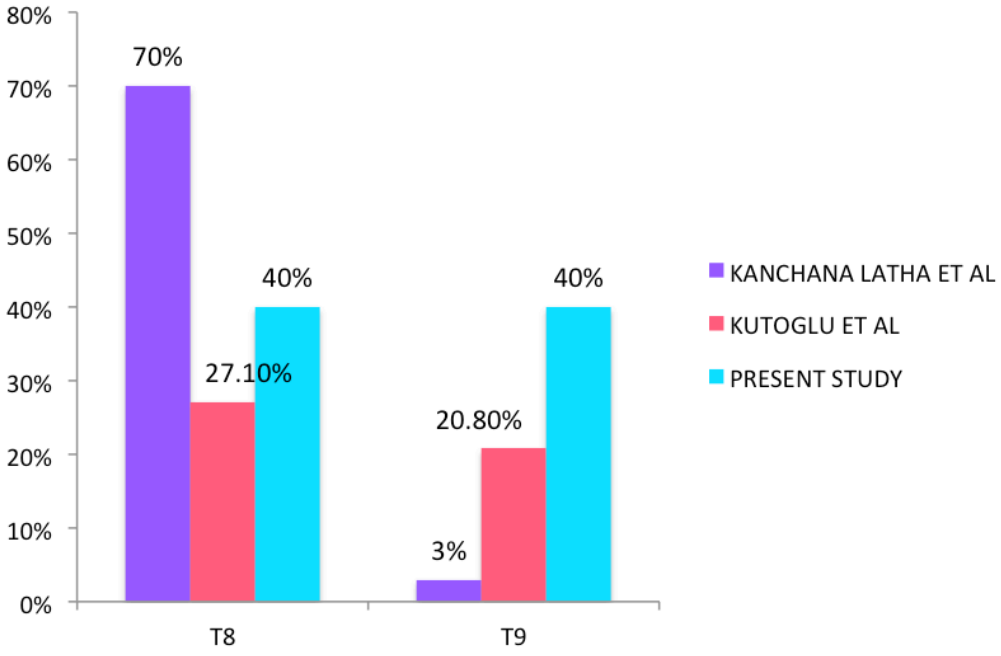


Chart 21: COMPARISON OF PRESNT STUDY WITH OTHER STUDIES, LEVEL OF TERMINATION OF HEMIAZYGOS VEIN AT T8, T9 VERTEBRAL LEVELS

DIAMETER OF AZYGOS AND HEMIAZYGOS VEINS AT THE LEVEL OF TERMINATION

According to Tatar et al (2008) [36], azygos vein diameter just at the level of termination into the superior vena cava is between 4.3 mm and 16 mm. and the mean diameter is 8.1 mm.

Trigaux et al [76] study states the diameter of the azygos vein at the termination is 10.4 ± 5 mm.

Kutoglu et al (2012) [71] states the mean diameter of the azygos vein is 8.56±1.26 mm at its termination.

On the basis of Fleischner's observation [25], the azygos vein, normally measuring about 0.9 cm, can be seen in 75 % of normal chest X- rays.

In this study, Azygos vein diameter just at the termination into the superior vena cava is between 3.1 mm and 12.6 mm and the mean diameter is 6.9 +/- 2.1mm.

Kutoglu et al (2012) [27] states 5.65±1.17 mm as the mean diameter for the hemiazygos vein at its termination.

In the present study hemiazygos vein mean diameter at the termination is 5.05+/-1.3 mm, which is comparable with the above study.

TYPE, PATTERN OF AZYGOS SYSTEM OF VEINS

According to Anson BJ [5] Type I is seen in 1%, Type II in 98% and Type III in 1% of all cases.

According to Kutoglu et al (2012) [71] 2.1 % is Type I, 91.7% is Type II, and 2.1% is Type III.

The cases of single column azygos vein Type III is reported 1–2% and 5% by Kadir S and Seib GA, respectively [38,63].

In the present study among the cadaveric specimens 86.7% belongs to type II, 6.7% to type III and 3.3% to type I and 3.3% is atypical.

Chart 22 shows the comparison of the type of azygos system of veins in the present study with that of Anson BJ and Kutoglu et al studies.

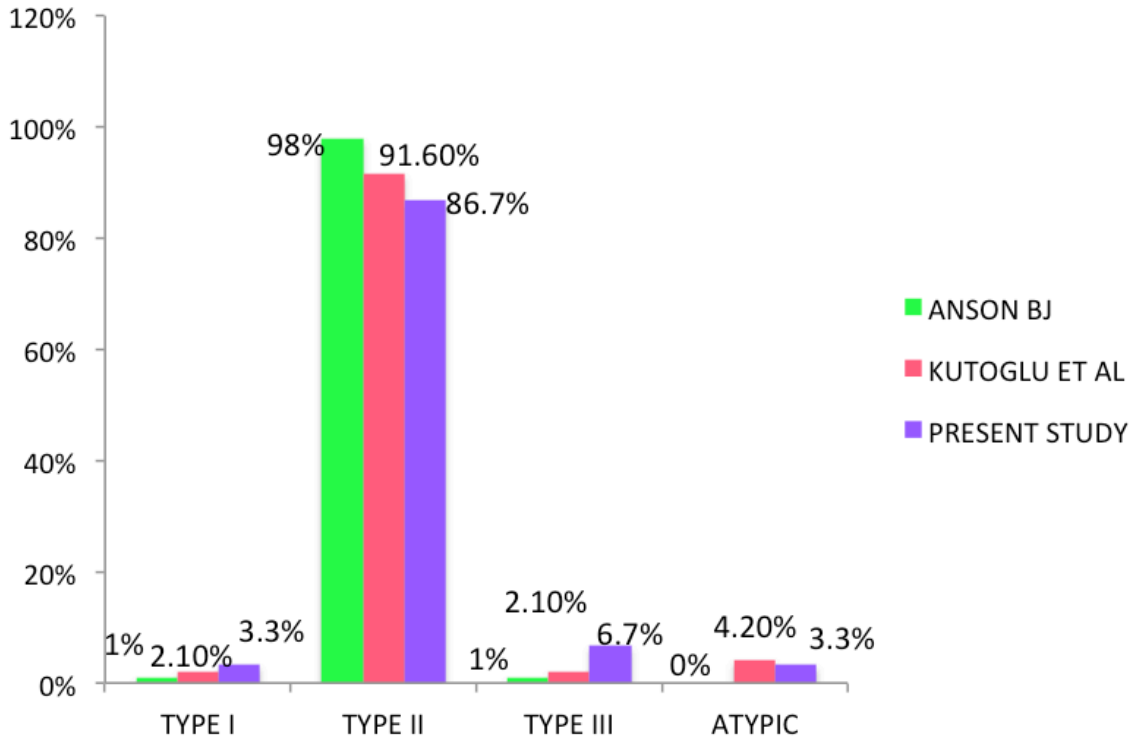


Chart 22: COMPARISON OF PRESENT STUDY WITH OTHER STUDIES, TYPE OF AZYGOS SYSTEM OF VEINS ACCORDING TO ANSONS SYSTEM OF CLASSIFICATION

In Kutoglu et al (2012) [71] study 2.1% is Group 1, 27.1% is Group 2, 2.1% is Group 3, 10.4% is Group 4, 10.4% is Group 5, 8.3% is Group 6A, 8.3% is Group 6B, 22.9% is Group 7, and 2.1% is Group 9, 2.1 % is Group 11 and 4.2% is atypical.

In this study Group I is present in 3.3%, Group 2 in 23.3%, Group 3 in 3.3% , Group 4 in 13.3% ,Group 5 in 10 %, Group 6 B in 6.7% ,Group 7 in 20% , Group 9 in 6.7% ,Group 10in 3.3% ,Group 11 in 6.7%. 3.3% (1

specimen) is classified as atypical as the pattern of azygos venous system is not fulfilling the above criteria. From both the studies we can infer that majority in Type II belong to Group 2 and Group 7.

Chart 23 shows the comparison of grouping of the specimens according to Anson's classification in the present study, with that of Kutoglu et al study.

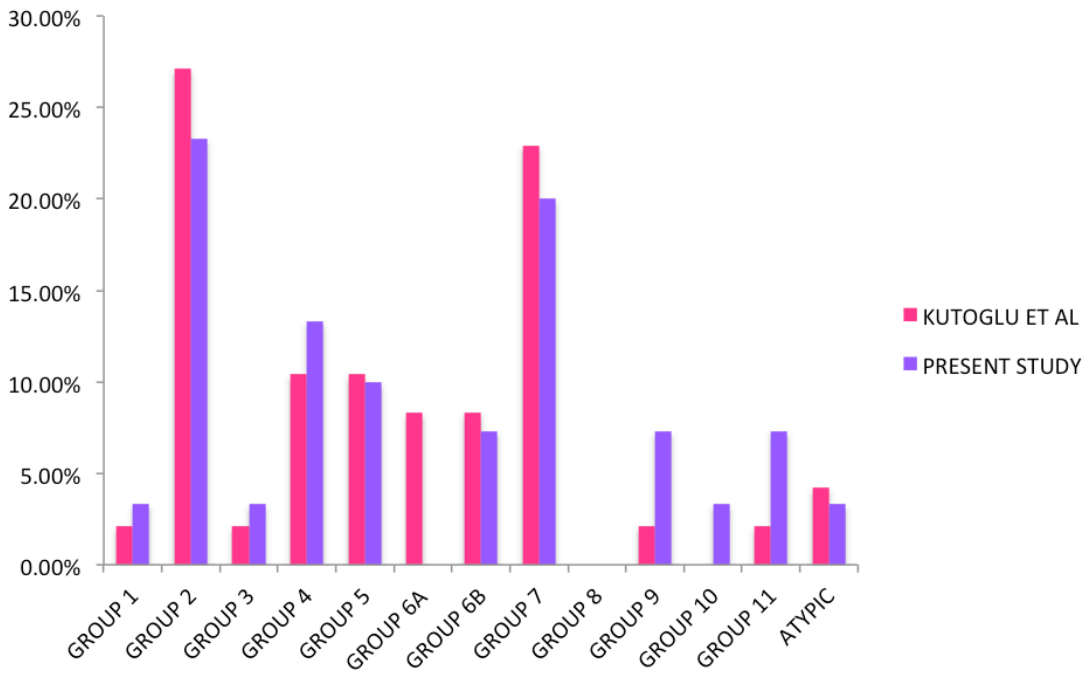


Chart 23: COMPARISON OF PRESENT STUDY WITH KUTOGLU ET AL STUDY, GROUPING OF AZYGOS SYSTEM OF VEINS ACCORDING TO ANSONS CLASSIFICATION

According to Tatar et al (2008) [36] hemiazygos vein is present in 87.4%. Hemiazygos vein is absent in 12.6% of the specimen. The hemiazygos and the accessory hemiazygos veins are incompletely formed in 15% of the individuals [81].

Ozbeck et al [56] has observed the absence of hemiazygos vein.

In the present study azygos vein is present in all the specimens (100%). Hemiazygos vein is absent in 14% (7 specimens). Accessory hemiazygos vein is absent in 28% (14 specimens).

The incidence of preaortic communications in azygos system of veins is noted to be 2.5% (Grysback) [31]

Morton et al [52] study observes pre aortic communicating channel between azygos and hemiazygos veins.

In an earlier study of 195 cadavers, preaortic crossing of the interazygos vein is observed in 3.6% of the cases [63] (Seib).

In the present study preaortic crossing of interazygos vein is not observed.

CONCLUSION

The Azygos venous system was studied and analyzed for the parameters taken by dissection method and also by analyzing radiologic images.

The results are charted out, statistically analyzed and correlated with the findings of already existing studies. The findings are summarized below:

1. Out of 30 cadaveric specimens studied, in 90% the azygos vein is formed by a single root that is the lateral root. Out of these in 23% only the subcostal vein forms it.

2. Among the 50 specimens, azygos vein is present to the right of midline of the vertebral column in 62%, to the left in 22% and in the midline in 16%.

3. Out of 50 specimens studied, the level of arching of azygos vein is at fourth vertebral level in 48% and the level of termination into superior venacava is at fourth vertebral level in 64 %. Azygos lobe is noted in the right lung in one radiologic specimen.

4. The level of termination of the hemiazygos vein is at the eighth and ninth thoracic vertebral level in 39.5 % each. Out of the 24 cadaveric specimens in which it is present, level of termination of the accessory hemiazygos vein is at sixth thoracic vertebral level in 42 %.

5. The mean diameter of the azygos vein just at the termination into the

superior vena cava is 6.9 +/-2.1mm. The diameter of the hemiazygos vein at the termination into the azygos vein is 5.05+/-1.3 mm.

6. Azygos vein is present in all the specimens (100%). Hemiazygos vein is not present in 14% .The mode of formation of the hemiazygos vein is mostly by the single root. Accessory hemiazygos vein is absent in 28%.

7. Among the 50 specimens analyzed 86.7% belongs to type II, 6.7% to type III and 3.3% to type I. Type I Group 1 is present in 3.3%, Type II Group 2 in 23.3%, Group 3 in 3.3%, Group 4 in 13.3%, Group 5 in 10%, Group 6B in 6.7% , Group 7 in 20% , Group 9 in 6.7% , Group 10 in 3.3 % , and Type III Group 11 in 6.7%. 3.3% is classified as atypical. There are no associated anomalies of the superior and the inferior vena cava.

It is very important to identify the anomalies of the azygos system in the computed tomography and magnetic resonance imaging of mediastinum. The variations in azygos venous system may easily be confused with aneurysm and other abnormalities like tumor and lymphadenopathy. It is important to have knowledge of these kinds of variations while performing the mediastinal operations or surgery of large vessels.
Comparison of computed tomography and magnetic resonance imaging scan studies of the azygos system of veins and surgical cadaveric models of the clinical conditions might be useful in the future.

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S.N	MODE OF FORM	REL TO MIDLINE	LEVEL OF ARCH	LEV OF TERM - AZY	DIA-AZY TER mm	HEMI AZY -P OR A	HA- MODE OF FORM	LEV OF TER- HA	DIA-HA TER mm	ACC HA- P OR A	ACC HA- LEV TER	TYPE	PATTERN
1	S,AL	R	4	3	5.4	P	S,AL	10	4.7	P	7	II	5
2	S,AL	R	4	4	6.9	P	S,AL	9	7.7	P	7	II	7
3	S,AL	L	5	4	4.7	P	S	7	3.7	P	7	II	3
4	S,AL	R	6	5	4.9	P	S,AL	9	3.6	P	9	II	2
5	S,AL	L	4	4	6.7	P	S,AL	9	3.2	P	6	II	6A
6	S	M	5	4	6.1	A				A		III	11
7	S,AL,INT ROOT	M	5	4	6.8	P	S,AL	8	4.2	P	6	II	2
8	S	R	4	3	5.6	P	S	9	4.5	P	6	II	5
9	S,AL	L	4	4	6.8	P	S,AL	9	5.8	P	6	II	7
10	S,AL,INT ROOT,MED ROOT	R	4	4	8.3	P	S,AL,MED ROOT	8	6.2	P	6	II	4
11	S,AL	R	6	5	5.3	P	S,AL	9	5	P	9	II	3
12	S,AL	M	6	6	5.6	P	S,AL	9	4.6	A		II	9
13	S,AL	R	5	4	6.1	P	S,AL	7	4.7	P	7	II	2
14	S,AL	M	4	3	5.9	A				A		III	11
15	S,AL	R	4	4	5.6	P	S,AL	8	3.8	P	6	II	7
16	S	R	5	5	6.3	P	S	9	4.3	P	9	II	3
17	S,AL	R	5	4	6.1	P	S,AL	7	3.3	P	7	II	3
18	S	R	4	4	7.1	P	S	8	6	A		II	10
19	S,AL	R	4	3	6.2	P	S,AL	7	5.1	P	5	II	7
20	S,AL	L	5	5	11.1	P	S,AL	10	7.9	P	7	II	4
21	S,AL	R	4	4	4.5	P	S,AL	7	4	P	7	II	2
22	S,AL	R	5	5	3.9	P	S,AL	9	3.7	P	9	II	4
23	S,AL,INT ROOT	L	6	5	5.7	P	S,AL	9	5.1	A		II	9
24	S,AL	L	5	4	7.5	P	S,AL	8	4.8	P	6	II	6A
25	S,AL	M	5	4	6.6	P	S	9	4.4	P	6	II	5
26	S	L	4	4	5.1	A				P	6	II	ATYPIC
27	S	R	4	4	10.3	P	S	10	5.1	P	8	II	4
28	S	L	5	4	4.7	P	S,AL	9	3.9	P	7	II	7
29	S,AL	R	4	4	5.3	A				A		III	11
30	S,AL	R	4	4	6.3	P	S,AL	9	3.8	P	6	II	7
31		R	5	4	7.8	P		8	6.8	A		II	
32		R	5	5	8.1	P		8	5.9	A		II	
33		R	4	4	12.6	P		8		P		I	
34		R	4	4	8.3	P		8	5.3	P		II	
35		L	5	4	9.1	P		8	6.1	P		II	
36		R	6	5	8.8	P		9	4.1	A		II	
37		M	4	4	12.1	A				A		III	
38		M	5	4	6.4	P		8	6.2	P		II	
39		R	4	3	4.7	P		9	4.3	P		II	
40		R	4	4	7.3	P		9	5.5	P		II	
41		R	4	4	6.9	P		8	5.2	A		II	
42		L	4	3	3.1	P		8	3.2	A		II	
43		R	6	5	7	P		7	7.1	P		II	
44		R	5	4	12	P		8	8.6	P		II	
45		L	4	4	8.3	A				A		III	
46		R	6	6	6.3	P		9	4.7	P		II	
47		R	4	4	6.7	P		8	5.8	P		II	
48	AZY LOBE	R	5	4	7.8	P		8	6.7	P		II	
49		M	5	5	9.4	A				A		III	
50		R	5	4	7.1	P		8	3.6	P		II	
					6.944				5.052				
					2.064				1.325				
					3.1				3.2				
					12.6				8.6				